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# PROCEEDINGS

OF

# THE AMERICAN ASSOCIATIO

FOR THE

# ADVANCEMENT OF SCIENCE.

## FIFTEENTH MEETING,

HELD AT BUFFALO, N. Y.,

AUGUST, 1866.

CAMBRIDGE:
PUBLISHED BY JOSEPH LOVERING.
1867.

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EDITED BY

JOSEPH LOVERING,

Permanent Secretary.

Cambridge Press.
DAKIN AND METCALF.

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### 2. *Committee to Memorialize the Legislature of West Virginia in Favor of a Geological Survey of the State.*

Prof. W. B. Rogers,
Prof. Louis Agassiz,
Prof. James Hall,
Prof. J. D. Dana,
Prof. J. S. Newberry,
Prof. E. B. Andrews.

### 3. *Committee to Memorialize Congress in Reference to the Hydrographical Survey of the Lakes.*

Prof. Joseph Henry,
Major-Gen. George G. Meade,
Dr. I. A Lapham,
Dr. J. E. Hilgard,
Col. C. Whittlesey.

### 4. *Committee to act with the Standing Committee in Nomination of Officers for the next Meeting.*

Section A.

Prof. C. S. Lyman,
Prof. O. N. Stoddard,
Prof. S. D. Tillman,
Prof. C. A. Joy.

Section B.

Prof. A. Winchell,
Prof. W. D. Whitney,
A. H. Worthen,
Prof. E. Hungerford.

# OFFICERS OF THE BURLINGTON MEETING.

Prof. J. S. Newberry, *President.*
Prof. Wolcott Gibbs, *Vice-President.*
Prof. Joseph Lovering, *Permanent Secretary.*
Prof. C. S. Lyman, *General Secretary.*
Dr. A. L. Elwyn, *Treasurer.*

## *Standing Committee.*

Prof. J. S. Newberry,
Prof. Wolcott Gibbs,
Prof. Joseph Lovering,
Prof. C. S. Lyman,
Pres. F. A. P. Barnard,
Dr. A. A. Gould,*
Prof. Elias Loomis,
Dr. A. L. Elwyn.

## *Local Committee.*

Hon. T. E. Wales, *Chairman.*
Prof. Edward Hungerford, *Secretary.*
James W. Hickok, *Treasurer.*

Albert Catlin,
Edward Peck,
Lawrence Barnes,
G. G. Benedict,
D. D. Howard,
G. F. Edmunds,
D. C. Linsley,
Prof. M. Buckham,
Henry Loomis.

---

* Died since the Buffalo Meeting.

## MEETINGS OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

| Meeting. | Date. | Place. | President. | Vice-President. | General Secretary. | Permanent Secretary. | Treasurer. |
|---|---|---|---|---|---|---|---|
| 1st, | Sept. 20, 1848, | Philadelphia, Pa., | W. C. Redfield, Esq., | | Prof. Walter R. Johnson, | | Prof. J. Wyman. |
| 2d, | Aug. 14, 1849, | Cambridge, Mass., | Prof. Joseph Henry, | | Prof. E. N. Hosford, | | Dr. A. L. Elwyn. |
| 3d, | March 12, 1850, | Charleston, S. C., | Prof. A. D. Bache,* | | Prof. L. R. Gibbes,* | | Dr. St. J. Ravenel.* |
| 4th, | Aug. 19, 1850, | New Haven, Ct., | Prof. A. D. Bache, | | E. C. Herrick, Esq., | | Dr. A. L. Elwyn. |
| 5th, | May 5, 1851, | Cincinnati, Ohio. | Prof. A. D. Bache, | | Prof. W. B. Rogers, | Prof. S. F. Baird, | Dr. A. L. Elwyn. |
| 6th, | Aug. 19, 1851, | Albany, N. Y., | Prof. L. Agassiz, | | Prof. W. B. Rogers, | Prof. S. F. Baird, | Dr. A. L. Elwyn. |
| 7th, | July 28, 1853, | Cleveland, Ohio, | Prof. Benj. Peirce, | | Prof. J. D. Dana, | Prof. S. F. Baird, | Dr. A. L. Elwyn. |
| 8th, | April 26, 1854, | Washington, D. C., | Prof. J. D. Dana, | | Prof. J. Lawrence Smith, | Prof. J. Lovering, | Dr. J. L. Le Conte.* |
| 9th, | Aug. 15, 1855, | Providence, R. I., | Prof. John Torrey, | | Prof. Wolcott Gibbs, | Prof. J. Lovering, | Dr. A. L. Elwyn. |
| 10th, | Aug. 20, 1856, | Albany, N. Y., | Prof. James Hall, | | Dr. B. A. Gould, | Prof. J. Lovering, | Dr. A. L. Elwyn. |
| 11th, | Aug. 12, 1857, | Montreal, C. E., | Prof. J. W. Bailey, | Prof. Alexis Caswell, | Prof. John Le Conte, | Prof. J. Lovering, | Dr. A. L. Elwyn. |
| 12th, | April 28, 1858, | Baltimore, Md., | Prof. A. Caswell,* | Prof. John E. Holbrook, | Prof. W. M. Gillespie, | Prof. J. Lovering, | Dr. A. L. Elwyn. |
| 13th, | Aug. 3, 1859, | Springfield, Mass., | Prof. S. Alexander, | Prof. Edw. Hitchcock, | Prof. William Chauvenet, | Prof. J. Lovering, | Dr. A. L. Elwyn. |
| 14th, | Aug. 1, 1860, | Newport, R. I., | Isaac Lea, LL.D., | Dr. B. A. Gould, | Prof. Joseph Le Conte, | Prof. J. Lovering, | Dr. A. L. Elwyn. |
| 15th, | Aug. 15, 1866, | Buffalo, N. Y., | Pres. F.A.P. Barnard. | Dr. A. A. Gould, | Prof. Elias Loomis, | Prof. J. Lovering, | Dr. A. L. Elwyn. |

* In the absence of the regular officer.

# CONSTITUTION OF THE ASSOCIATION.[1]

## OBJECTS.

THE Association shall be called "The American Association for the Advancement of Science." The objects of the Association are, by periodical and migratory meetings, to promote intercourse between those who are cultivating science in different parts of the United States; to give a stronger and more general impulse, and a more systematic direction, to scientific research in our country; and to procure for the labors of scientific men increased facilities and a wider usefulness.

## MEMBERS.

RULE 1. Members of scientific societies or learned bodies having in view any of the objects of this Association, and publishing transactions, shall be considered members on subscribing these rules.

RULE 2. Collegiate professors, also civil engineers and architects who have been employed in the construction or superintendence of public works, may become members on subscribing these rules.

RULE 3. Persons not embraced in the above provisions may become members of the Association upon recommendation in writing by two members, nomination by the Standing Committee, and election by a majority of the members present.

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[1] Adopted August 25, 1856, and ordered to go into effect at the opening of the Montreal Meeting.

### OFFICERS.

RULE 4. The officers of the Association shall be a President, Vice-President, General Secretary, Permanent Secretary, and Treasurer. The President, Vice-President, General Secretary, and Treasurer, shall be elected at each meeting for the following one; — the three first-named officers not to be reëligible for the next two meetings, and the Treasurer to be reëligible as long as the Association may desire. The Permanent Secretary shall be elected at each second meeting, and also be reëligible as long as the Association may desire.

### MEETINGS.

RULE 5. The Association shall meet, at such intervals as it may determine, for one week or longer, — the time and place of each meeting being determined by a vote of the Association at the previous meeting; and the arrangements for it shall be intrusted to the officers and the Local Committee.

### STANDING COMMITTEE.

RULE 6. There shall be a Standing Committee, to consist of the President, Vice-President, Secretaries, and Treasurer of the Association; the officers of the preceding year, the permanent chairman of the Sectional Committees, after these shall have been organized, and six members present from the Association at large who shall have attended any of the previous meetings, to be elected upon open nomination by ballot on the first assembling of the Association. A majority of the whole number of votes cast to elect. The General Secretary shall be Secretary of the Standing Committee.

The duties of the Standing Committee shall be, —

1. To assign papers to the respective sections.

2. To arrange the scientific business of the general meetings, to suggest topics and arrange the programmes for the evening meetings.

3. To suggest to the Association the place and time of the next meeting.

4. To examine, and, if necessary, to exclude papers.

5. To suggest to the Association subjects for scientific reports and researches.

6. To appoint the Local Committee.

7. To have the general direction of publications.

8. To manage any other general business of the Association during the session, and during the interval between it and the next meeting.

9. In conjunction with four from each Section, to be elected by the Sections for the purpose, to make nominations of officers of the Association for the following meeting.

10. To nominate persons for admission to membership.

11. Before adjourning, to decide which papers, discussions, or other proceedings shall be published.

### SECTIONS.

RULE 7. The Association shall be divided into two Sections, and as many sub-Sections as may be necessary for the scientific business, the manner of division to be determined by the Standing Committee of the Association. The two Sections may meet as one.

### SECTIONAL OFFICERS AND COMMITTEES.

RULE 8. On the first assembling of the Section, the members shall elect upon open nomination a permanent chairman and secretary, also three other members, to constitute, with these officers, a Sectional Committee.

The Section shall appoint, from day to day, a chairman to preside over its meetings.

RULE 9. It shall be the duty of the Sectional Committee of each Section to arrange and direct the proceedings in their Section; to ascertain what communications are offered; to assign the order in which these communications shall appear, and the amount of time which each shall occupy.

The Sectional Committees may likewise recommend subjects for systematic investigation by members willing to undertake the researches, and to present their results at the next meeting.

The Sectional Committees may likewise recommend reports on particular topics and departments of science, to be drawn up as occasion permits, by competent persons, and presented at subsequent meetings.

### REPORTS OF PROCEEDINGS.

RULE 10. Whenever practicable, the proceedings shall be reported by professional reporters or stenographers, whose reports are to be revised by the secretaries before they appear in print.

### PAPERS AND COMMUNICATIONS.

RULE 11. No paper shall be placed in the programme, unless admitted by the Sectional Committee; nor shall any be read, unless an abstract of it has been previously presented to the Secretary of the Section, who shall furnish to the chairman the titles of papers of which abstracts have been received.

RULE 12. The author of any paper or communication shall be at liberty to retain his right of property therein, provided he declare such to be his wish before presenting it to the Association.

RULE 13. Copies of all communications, made either to the General Association or to the Sections, must be furnished by the authors; otherwise only the titles or abstracts shall appear in the published proceedings.

RULE 14. All papers, either at the general or in the sectional meetings, shall be read, as far as practicable, in the order in which they are entered upon the books of the Association; except that those which may be entered by a member of the Standing Committee of the Association shall be liable to postponement by the proper Sectional Committee.

RULE 15. If any communication be not ready at the assigned time, it shall be dropped to the bottom of the list, and shall not be entitled to take precedence of any subsequent communication.

RULE 16. No exchanges shall be made between members without authority of the respective Sectional Committees.

### GENERAL AND EVENING MEETINGS.

RULE 17. The Standing Committee shall appoint any general meeting which the objects and interests of the Association may call for, and the evenings shall, as a rule, be reserved for general meetings of the Association.

These general meetings may, when convened for that purpose, give their attention to any topics of science which would otherwise come before the Sections.

It shall be a part of the business of these general meetings to receive the Address of the President of the last meeting; to hear such reports on scientific subjects as, from their general importance and interests, the Standing Committee shall select; also to receive from the chairmen of the Sections abstracts of the proceedings of their respective Sections; and to listen to communications and lectures explanatory of new and important discoveries and researches in science, and new inventions and processes in the arts.

### ORDER OF PROCEEDINGS IN ORGANIZING A MEETING.

RULE 18. The Association shall be called to order by the President of the preceding meeting, and this officer having resigned the chair to the President elect, the General Secretary shall then report the number of papers relating to each department which have been registered, and the Association consider the most eligible distribution into Sections, when it shall proceed to the election of the additional members of the Standing Committee in the manner before described; the meeting shall then adjourn, and the Standing Committee, having divided the Association into Sections as directed, shall allot to each its place of meeting for the Session. The Sections shall then organize by electing their officers and their representatives in the Nominating Committee, and shall proceed to business.

### PERMANENT SECRETARY.

RULE 19. It shall be the duty of the Permanent Secretary to notify members who are in arrears, to provide the necessary stationery and suitable books for the list of members and titles of papers, minutes of the general and sectional meetings, and for other purposes indicated in the rules, and to execute such other duties as may be directed by the Standing Committee or by the Association.

The Permanent Secretary shall make a report annually to the Standing Committee, at its first meeting, to be laid before the Association, of the business of which he has had charge since its last meeting.

All members are particularly desired to forward to the Permanent Secretary, so as to be received before the day appointed for the Association to convene, complete titles of all the papers which they expect to present during its meeting, with an estimate of the time required for reading each, and such abstracts of their contents as may give a general idea of their nature.

Whenever the Permanent Secretary notices any error of fact or unnecessary repetition, or any other important defect in the papers communicated for publication in the proceedings of the Association, he is authorized to commit the same to the author, or to the proper sub-committee of the Standing Committee for correction.

### LOCAL COMMITTEE.

RULE 20. The Local Committee shall be appointed from among members residing at or near the place of meeting for the ensuing year; and it shall be the duty of the Local Committee, assisted by the officers, to make arrangements and the necessary announcements for the meeting.

The Secretary of the Local Committee shall issue a circular in regard to the time and place of meetings, and other particulars, at least one month before each meeting.

### SUBSCRIPTIONS.

RULE 21. The amount of the subscription, at each meeting, of each member of the Association shall be two dollars, and one dollar in addition shall entitle him to a copy of the proceedings of the annual meeting. These subscriptions shall be received by the Permanent Secretary, who shall pay them over, after the meeting, to the Treasurer.

No person shall be considered a member of the Association until the subscription for the meeting at which he is elected has been paid.

RULE 22. The names of all persons two years in arrears for annual dues shall be erased from the list of members; provided that two notices of indebtedness, at an interval of at least three months, shall have been previously given.

### ACCOUNTS.

RULE 23. The accounts of the Association shall be audited annually, by auditors appointed at each meeting.

### ALTERATIONS OF THE CONSTITUTION.

RULE 24. No article of this constitution shall be altered, or amended, or set aside, without the concurrence of three-fourths of the members present, and unless notice of the proposed change shall have been given at the preceding annual meeting.

NOTE. — A proposition to alter Rule 21 of the Constitution, so that an additional initiation fee of five dollars will be charged in addition to the annual assessment upon new members, was proposed at Buffalo, and will come up for action at the Burlington meeting.

# RESOLUTIONS

OF A

# PERMANENT AND PROSPECTIVE CHARACTER,

ADOPTED AUGUST 19, 1857.

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1. No appointment may be made in behalf of the Association, and no invitation given or accepted, except by vote of the Association or its Standing Committee.

2. The General Secretary shall transmit to the Permanent Secretary for the files, within two weeks after the adjournment of every meeting, a record of the proceedings of the Association and the votes of the Standing Committee. He shall also daily, during the meetings, provide the chairmen of the two Sectional Committees with lists of the papers assigned to their Sections by the Standing Committee.

3. All printing for the Association shall be superintended by the Permanent Secretary, who is authorized to employ a clerk for that especial purpose.

4. The Permanent Secretary is authorized to put the proceedings of the meetings to press one month after the adjournment of the Association. Papers which have not been received at that time may be published only by title. No notice of articles not approved shall be taken in the published proceedings.

5. The Permanent Chairmen of the Sections are to be considered their organs of communication with the Standing Committee.

6. It shall be the duty of the Secretaries of the two Sections to receive copies of the papers read in their Sections, all sub-sections included, and to furnish them to the Permanent Secretary at the close of the meeting.

7. The Sectional Committees shall meet not later than 9 A. M. daily during the meetings of the Association, to arrange the programmes of their respective Sections, including all sub-sections, for the following day. No paper shall be placed upon these programmes which shall not have been assigned to the Section by the Standing Committee. The programmes are to be furnished to the Permanent Secretary not later than 11 A. M.

8. During the meetings of the Association the Standing Committee shall meet daily, Sundays excepted, at 9 A. M., and the Sections be called to order at 10 A. M., unless otherwise ordered. The Standing Committee shall also meet on the evening preceding the first assembling of the Association at each annual meeting, to arrange for the business of the first day, and on this occasion three shall form a quorum.

9. Associate members may be admitted for one, two, or three years, as they shall choose at the time of admission, — to be elected in the same way as permanent members, and to pay the same dues. They shall have all the social and scientific privileges of members, without taking part in the business.

10. No member may take part in the organization and business arrangement of both the Sections.

# MEMBERS

OF THE

# AMERICAN ASSOCIATION

FOR THE

# ADVANCEMENT OF SCIENCE.

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**Note.**—Names of deceased members are marked with an asterisk (*). The figure at the end of each name refers to the meeting at which the election took place.

## A.

*Adams, Prof. C. B., Amherst, Massachusetts [1].
Aiken, Prof. W. E. A., Baltimore, Maryland [12].
Ainsworth, J. G., Barry, Massachusetts [14].
Albert, Augustus J., Baltimore, Maryland [12].
Alexander, Prof. Stephen, Princeton, New Jersey [1].
Allen, Prof. E. A. H., New Bedford, Massachusetts [6].
Allen, Zachariah, Providence, Rhode Island [1].
Allen, Mary B., Rochester, New York [15].
*Ames, M. P., Springfield, Massachusetts [1].
Andrews, Prof. E. B., Marietta, Ohio [7].
*Appleton, Nathan, Boston, Massachusetts [1].
Avery, Prof. Charles, Clinton, New York [10].

## B.

*Bache, Prof. Alexander D., Washington, District of Columbia [1].
Bache, Dr. Franklin, Philadelphia, Pennsylvania [1].
Bacon, Dr. John, Jr., Boston, Massachusetts [1].
*Bailey, Prof. J. W., West Point, New York [1].
Baird, Prof. S. F., Washington, District of Columbia [1].
Bardwell, Prof. F. W., Jacksonville, Florida [13].
Barker, George F., Boston, Massachusetts [13].
Barlow, Thomas, Canastota, New York [7].
Barnard, Pres. F. A. P., New York, New York [7].
Barnard, Henry, Madison, Wisconsin [12].
Barnard, J. G., U. S. A., Washington, District of Columbia [14].
Barnes, Capt. James, Springfield, Massachusetts [5].
Barratt, Dr. Joseph, Middletown, Connecticut [13].
Bartlett, Prof. W. H. C., West Point, New York [9].
Basnett, Thomas, Ottawa, Illinois [8].
Batchelder, J. M., Cambridge, Massachusetts [8].
Beadle, Rev. E. R., Hartford, Connecticut [10].
Bebb, M. S., Rockford, Illinois [13].
*Beck, Dr. C. F., Philadelphia, Pennsylvania [1].
*Beck, Prof. Lewis C., New Brunswick, New Jersey [1].
*Beck, Dr. T. Romeyn, Albany, New York [1].
Bell, Samuel N., Manchester, New Hampshire [7].
Bentley, Cyrus, Chicago, Illinois [13].
Bigelow, Artemas, Newark, New Jersey [9].
*Binney, Dr. Amos, Boston, Massachusetts [1].
*Binney, John, Boston, Massachusetts [3].
Bird, Col. William A., Buffalo, New York [15].
Blair, Prof. F. O., Lebanon, Illinois [13].
Blake, Prof. Eli W., Burlington, Vermont [15].
Blake, Eli W., New Haven, Connecticut [1].
Blake, J. R., La Grange, Tennessee [10].
*Blanding, Dr. William, Rhode Island [1].
Blaney, Prof. James V. Z., Chicago, Illinois [12].
*Bomford, Col. George, Washington, District of Columbia [1].
Bouve, Thomas T., Boston, Massachusetts [1].
Bowditch, Dr. Henry J., Boston, Massachusetts [2].

Boynton, Prof. Edward C., Syracuse, New York [13].
Bradford, Isaac, Jacksonville, Florida [14].
Bradish, Alvah, Fredonia, New York [15].
Bradley, Dr. L., Jersey City, New Jersey [15].
Brayley, James, Buffalo, New York [15].
Brevoort, J. Carson, Brooklyn, New York [1].
Brewer, Fisk P., New Haven, Connecticut [11].
Briggs, A. D., Springfield, Massachusetts [13].
Brocklesby, Prof. John, Hartford, Connecticut [4].
Bross, William, Chicago, Illinois [7].
Brown, Andrew, Natchez, Mississippi [1].
Brown, Richard, Sydney, Cape Breton [1].
Brown, Robert, Jr., Cincinnati, Ohio [11].
Brush, George J., New Haven, Connecticut [11].
Buchanan, Robert, Cincinnati, Ohio [2].
Buck, C. E., NewYork, New York [15].
*Burnap, Rev. G. W., Baltimore, Maryland [12].
*Burnett, Waldo I., Boston, Massachusetts [1].
Busher, James, Worcester, Massachusetts [9].
Butler, Prof. James D., Madison, Wisconsin [13].
Butler, Hon. Thomas B., Norwalk, Connecticut [10].

## C.

Cabell, Prof. James L., University of Virginia, Virginia [6].
*Carpenter, Thornton, Camden, South Carolina [7].
*Carpenter, Dr. William M., New Orleans, Louisiana [1].
Carr, E. S., Albany, New York [9].
Case, Leonard, Cleveland, Ohio [15].
*Case, William, Cleveland, Ohio [6].
Cassells, Prof. J. L., Cleveland, Ohio [7].
Caswell, Prof. Alexis, Providence, Rhode Island [2].
Cattell, Rev. William C., Easton, Pennsylvania [15].
Chadbourne, Prof. P. A., Williamstown, Massachusetts [10].
Chapin, A. L., Beloit, Wisconsin [14].
Chapin, L. C., New Haven, Connecticut [11].
Chapman, Prof. C. B., Madison, Wisconsin [11].
*Chapman, Dr. N., Philadelphia, Pennsylvania [1].

Chase, Prof. George I., Providence, Rhode Island [1].
*Chase, Prof. S., Dartmouth, New Hampshire [2].
Chauvenet, Prof. William, St. Louis, Missouri [1].
Chesbrough, E. S., Chicago, Illinois [2].
Chester, Albert H., New York, New York [15].
Chester, Rev. Albert T., Buffalo, New York [15].
*Chittenden, L. E., Burlington, Vermont [14].
Church, Prof. A. E., West Point, New York [10].
Churchill, Marlborough, Sing Sing, New York [13].
Clapp, Almon M., Buffalo, New York [15].
*Clapp, Dr. Asahel, New Albany, Indiana [1].
*Clark, Joseph, Cincinnati, Ohio [5].
Clark, M. Lewis, St. Louis, Missouri [5].
Clarke, Dr. A. B., Holyoke, Massachusetts [13].
Clarke, Henry, M. D., Worcester, Massachusetts [14].
Cleaveland, Prof. C. H., Cincinnati, Ohio [9].
*Cleveland, Dr. A. B., Cambridge, Massachusetts [2].
Clinton, George W., Buffalo, New York [15].
Clum, Henry A., New York, New York [9].
Coakley, Prof. George W., New York, New York [5].
Cobleigh, Pres. Nelson E., Lebanon, Illinois [13].
Cochran, D. H., Brooklyn, New York [15].
Coffin, C. C., Malden, Massachusetts [13].
Coffin, Prof. James H., Easton, Pennsylvania [1].
Coffin, Prof. John H. C., Washington, District of Columbia [1].
*Cole, Thomas, Salem, Massachusetts [1].
*Coleman, Rev. Henry, Boston, Massachusetts [1].
Comstock, C. B., West Point, New York [14].
Conant, Marshall, Washington, District of Columbia [7].
Conkling, Frederick A., New York, New York [11].
Conway, Rev. M. D., Cincinnati, Ohio [14].
Cook, Prof. George H., New Brunswick, New Jersey [6].
Copes, Dr. Joseph S., New Orleans, Louisiana [11].
Corning, Hon. Erastus, Albany, New York [6].
Coryell, Thomas D., Madison, Wisconsin [13].
Couper, J. Hamilton, Darien, Georgia [1].
Craig, Dr. B. F., Washington, District of Columbia [15].
Cramp, Rev. J. M., Acadia College, Nova Scotia [11].

Credner, Herman, New York, New York [15].
Crosby, Alpheus, Salem, Massachusetts [10].
Cummings, Pres. Joseph, Middletown, Connecticut [13].
Curry, Rev. W. F., Geneva, New York [11].
Curtiss, Charles W., Evanston, Illinois [13].

D.

Dakin, Francis E., Freeport, Illinois [10].
Dalrymple, Rev. E. A., Baltimore, Maryland [11].
Dana, Prof. James D., New Haven, Connecticut [1].
Danforth, Edward, Troy, New York [11].
Davies, Prof. Charles, Fishkill, New York [10].
Davis, James, Jr., Boston, Massachusetts [1].
Dawson, Prof. J. W., Montreal, Canada [10].
Dean, Prof. Amos, Albany, New York [6].
Dean, George W., Fall River, Massachusetts [15].
*Dearborn, George H. A. S., Roxbury, Massachusetts [1].
*DeKay, Dr. James E., New York, New York [1].
Delafield, Joseph, New York, New York [1].
Delano, Joseph C., New Bedford, Massachusetts [5].
Denson, Claudius B., Pittsboro, North Carolina [12].
Dewey, Prof. Chester, Rochester, New York [1].
Dexter, G. M., Boston, Massachusetts [11].
Dexter, James, Albany, New York [6].
Dinwiddie, Robert, New York, New York [1].
Dixwell, Epes S., Cambridge, Massachusetts [1].
Dobbins, David P., Buffalo, New York [15].
Dorr, E. P., Buffalo, New York [15].
Dow, Prof. George W., Chicago, Illinois [13].
Downes, John, Washington, District of Columbia [10].
Drowne, Prof. Charles, Troy, New York [6].
*Ducatel, Dr. J. T., Baltimore, Maryland [1].
Duffield, Rev. George, Detroit, Michigan [10].
*Dumont, Rev. A. H., Newport, Rhode Island [14].
*Duncan, Lucius C., New Orleans, Louisiana [10].
Dunn, Prof. R. P., Providence, Rhode Island [14].
Dunn, T. C., M. D., Newport, Rhode Island [14].
Dwinelle, William H., New York, New York [10].
Dyer, Elisha, Providence, Rhode Island [9].

## E.

Easton, Norman, Fall River, Massachusetts [14].
Eastwood, George, Saxonville, Massachusetts [13].
Eaton, Daniel C., New Haven, Connecticut [13].
Eggleston, Rev. N. H., Madison, Wisconsin [13].
Eliot, Prof. Charles W., Cambridge, Massachusetts [14].
Elliott, Ezekiel B., Boston, Massachusetts [10].
Elwyn, Dr. Alfred L., Philadelphia, Pennsylvania [1].
Ely, George H., Rochester, New York [13].
Emerson, George B., Boston, Massachusetts [1].
Engelmann, Dr. George, St. Louis, Missouri [1].
Engstrom, A. B., Burlington, New Jersey [1].
Eustis, Prof. Henry L., Cambridge, Massachusetts [2].
Evans, Charles W., Buffalo, New York [15].
*Everett, Edward, Boston, Massachusetts [2].
Everett, J. D., Winsor, Nova Scotia [14].
Ewing, Thomas, Lancaster, Ohio [5].

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Fairbanks, Prof. Henry, Hanover, New Hampshire [14].
Farnham, Thomas, Buffalo, New York [15].
Ferrell, William, Nashville, Tennessee [11].
Ferris, Rev. Dr. Isaac, New York, New York [6].
Feuchtwanger, Dr. Louis, New York, New York [11].
Field, Roswell, Greenfield, Massachusetts [13].
Fillmore, Millard, Buffalo, New York [7].
Fish, George T., Rochester, New York [15].
Fisher, Mark, Trenton, New Jersey [10].
*Fitch, Alexander, Hartford, Connecticut [1].
Fitch, Edward H., Ashtabula, Ohio [11].
Fitch, O. H., Ashtabula, Ohio [7].
Folsom, George, New York, New York [11].
Forbush, E. B., Buffalo, New York [15].
Force, Dr. Charles F., Washington, District of Columbia [12].
Force, Col. Peter, Washington, District of Columbia [4].
Fosgate, Dr. Blanchard, Auburn, New York [7].

Foster, J. W., Chicago, Illinois [1].
Fowle, William B., Boston, Massachusetts [1].
*Fox, Rev. Charles, Grosse Isle, Michigan [7].
Frazer, Prof. John F., Philadelphia, Pennsylvania [1].
Fristoe, Edward T., Washington, District of Columbia [11].
Frost, Charles C., Brattleboro, Vermont [13].
Frothingham, Rev. Frederick, Brattleboro, Vermont [11].

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Gale, L. D., Washington, District of Columbia [8].
Gavit, John E., New York, New York [1].
*Gay, Dr. Martin, Boston, Massachusetts [1].
Gay, Dr. C. C. F., Buffalo, New York [15].
Gibbes, Prof. L. R., Charleston, South Carolina [1].
Gibbon, Dr. J. H., Charlotte, North Carolina [3].
Gibbs, Dr. Wolcott, Cambridge, Massachusetts [1].
Gillespie, Prof. W. M., Schenectady, New York [10].
Gillmore, Q. A., Jr., U. S. A., New York, New York [13].
Gilman, Daniel C., New Haven, Connecticut [10].
*Gilmor, Robert, Esq., Baltimore, Maryland [1].
Glynn, Com. James, U. S. N., New Haven, Connecticut [1].
Gold, Stephen A., New Haven, Connecticut [13].
Gold, Theodore S., West Cornwall, Connecticut [4].
Goodwin, William F., Concord, New Hampshire [10].
*Gould, Dr. Augustus A., Boston, Massachusetts [11].
*Gould, B. A., Boston, Massachusetts [2].
Gould, Dr. B. A., Cambridge, Massachusetts [2].
*Graham, Col. James D., U. S. A., Washington, D. C. [1].
Gray, Prof. Alonzo, Brooklyn, New York [13].
Gray, Prof. Asa, Cambridge, Massachusetts [1].
*Gray, Dr. James H., Springfield, Massachusetts [6].
Green, Horace, New York, New York [10].
Green, Dr. Traill, Easton, Pennsylvania [1].
*Greene, Dr. Benjamin D., Boston, Massachusetts [1].
Greene, Dr. F. C., East Hampton, Massachusetts [11].
Greene, Samuel, Woonsocket, Rhode Island [9].
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Gummere, Samuel J., Burlington, New Jersey [7].
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Haines, William S., Providence, Rhode Island [9].
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*Hale, Dr. Enoch, Boston, Massachusetts [1].
Hall, Prof. James, Albany, New York [1].
Hall, Joel, Athens, Illinois [7].
Hamlin, A. C., Bangor, Maine [10].
Hammond, Rev. Charles, Groton, Massachusetts [13].
Hammond, George T., Newport, Rhode Island [14].
Hance, Ebenezer, Morrisville, Pennsylvania [7].
Hand, Thomas J., Baltimore, Maryland [12].
Hanover, M. D., Cincinnati, Ohio [13].
*Hare, Dr. Robert, Philadelphia, Pennsylvania [11].
*Harlan, Prof. Joseph G., Haverford, Pennsylvania [8].
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Harman, Rev. Henry M., Baltimore, Maryland [12].
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Harrison, B. F., Wallingford, Connecticut [11].
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Hartshorne, Dr. Henry, Philadelphia, Pennsylvania [12].
Harvey, Dr. Charles W., Buffalo, New York [15].
Harvey, Leon F., Buffalo, New York [15].
Haven, Samuel F., Worcester, Massachusetts [9].
*Hayden, Dr. H. H., Baltimore, Maryland [1].
Hayes, George E., Buffalo, New York [15].
*Hayward, James, Boston, Massachusetts [1].
Hazard, Rowland, Peace Dale, Rhode Island [9].
Hedrick, B. S., New York, New York [13].
Henry, Prof. Joseph, Washington, District of Columbia [1].
Herzen, Rev. W., Delaware, Ohio [15].
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Hilgard, Eugene W., Oxford, Mississippi [11].
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Hill, S. W., Hancock, Lake Superior [6].
Hill, Pres. Thomas, Cambridge, Massachusetts [3].
Hitchcock, Charles H., Amherst, Massachusetts [11].
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Hoadley, E. S., Springfield, Massachusetts [13].
Hodgson, W. B., Savannah, Georgia [10].
Holland, Joseph B., Westfield, Massachusetts [9].
Holton, L. H., Montreal, Canada [11].
Homes, Henry A., Albany, New York [11].
Horsford, Rev. Benjamin F., Haverhill, Massachusetts [13].
Horsford, Prof. E. N., Cambridge, Massachusetts [1].
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Hough, Dr. Franklin B., Lowville, New York [4].
Hough, G. W., Albany, New York [15].
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Howland, Theodore, Buffalo, New York [15].
Howard, Dr. Benjamin, Williamstown, Massachusetts [13].
Howell, Robert, Nichols, New York [6].
Hubbard, Prof. Oliver P., Hanover, New Hampshire [1].
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Johnston, A. K., Platteville, Wisconsin [13].
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King, Dr. David, Newport, Rhode Island [13].
Kirkpatrick, Prof. James A., Philadelphia, Pennsylvania [7].
Kirkwood, Prof. Daniel, Canonsburg, Pennsylvania [7].
Kite, Thomas, Cincinnati, Ohio [5].
Kittredge, Dr. Josiah, South Hadley, Massachusetts [11].
Knox, Rev. J. P., Newtown, Long Island [11].

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Lapham, Increase A., Milwaukee, Wisconsin [3].
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Lattimore, Prof. S. A., Lima, New York [15].
Lauderdale, John V., Geneseo, New York [10].
Lawrence, Prof. Edward A., East Windsor, Connecticut [13].
Lawrence, George N., New York, New York [7].
Lea, Isaac, Philadelphia, Pennsylvania [1].

Le Conte, Dr. John L., Philadelphia, Pennsylvania [1].
Le Conte, Prof. John, Columbia, South Carolina [3].
Le Conte, Dr. Joseph, Columbia, South Carolina [3].
*Lederer, Baron von, Washington, District of Columbia [1].
Lee, John R., Buffalo, New York [15].
Leonard, Dr. A. M., Lockport, New York [15].
Lesley, J. P., Philadelphia, Pennsylvania [2].
Lesley, Joseph, Jr., Philadelphia, Pennsylvania [8].
Letchworth, William P., Portage, New York [15].
*Lieber, Oscar M., Columbia, South Carolina [8].
*Lincklaen, Ledyard, Cazenovia, New York [1].
Lindsley, Dr. J. B., Nashville, Tennessee [1].
*Linsley, Rev. James H., Stafford, Connecticut [1].
Little, Dr. George, Oakland, Mississippi [15].
Litton, Prof. A., St. Louis, Missouri [12].
Locke, Prof. Joseph M., Cincinnati, Ohio [13].
Locke, Dr. Luther F., Nashua, New Hampshire [7].
Logan, Sir William E., Montreal, Canada [1].
Loomis, Prof. Elias, New Haven, Connecticut [1].
Loomis, Prof. L. C., Wheeling, West Virginia [9].
Loomis, Dr. Silas L., Washington, District of Columbia [7].
Loosey, Charles F., New York, New York [12].
Lord, Rev. John, Stamford, Connecticut [13].
Lovering, Prof. Joseph, Cambridge, Massachusetts [2].
Lothrop, Dr. Joshua R.; Buffalo, New York [15].
Lunn, William, Montreal, Canada [11].
Lyman, Prof. Chester S., New Haven, Connecticut [4].
Lyman, B. S., Philadelphia, Pennsylvania [15].
Lyman, Henry, Montreal, Canada [11].

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Marissal, F. V., Fall River, Massachusetts [14].
Marsh, Prof. O. C., New Haven, Connecticut [15].
Marshall, Charles D., Buffalo, New York [15].
Marshall, Orasmus H., Buffalo, New York [15].
McCall, John, Utica, New York [10].
McChesney, J. H., Springfield, Illinois [11].
M'Conihe, Isaac, Troy, New York [4].

McCord, J. L., Montreal, Canada [11].
McRae, John, Camden, South Carolina [3].
Macy, Alfred, Nantucket, Massachusetts [13].
Mahan, Prof. D. H., West Point, New York [9].
Mallett, Prof. J. W., Tuscaloosa, Alabama [10].
Marcy, Oliver, Evanston, Illinois [10].
*Marsh, Dexter, Greenfield, Massachusetts [1].
Martin, Prof. W. J., Chapel Hill, North Carolina [12].
*Mather, William W., Columbus, Ohio [1].
Mauran, Dr. J., Providence, Rhode Island [2].
Mayhew, Prof. D. P., Ypsilanti, Michigan [13].
Maynard, Dr. Alleyne, Cleveland, Ohio [7].
Meade, Gen. George G., Philadelphia, Pennsylvania [15].
Means, Prof. A., Oxford, Georgia [5].
Meech, L. W., Preston, Connecticut [8].
Meek, F. B., Washington, District of Columbia [6].
Meigs, Prof. James A., Philadelphia, Pennsylvania [12].
Merrill, Hubert H., Lebanon, Tennessee [13].
Miles, Prof. Henry H., Lennoxville, Canada East [11].
Miller, Samuel, New Haven, Connecticut [14].
Minifie, William, Baltimore, Maryland [12].
Mitchell, Maria, Poughkeepsie, New York [4].
Mitchell, William, Poughkeepsie, New York [2].
Montague, Theodore L., Pomeroy, Ohio [13].
Morgan, DeWitt C., M. D., Baltimore, Maryland [14].
Morgan, Lewis H., Rochester, New York [10].
Morris, D., Ellingham, Connecticut [14].
Morris, J. R., Houston, Texas [11].
Morris, Rev. John G., Baltimore, Maryland [12].
Morrison, Benjamin F., Nantucket, Massachusetts [13].
Morse, Charles M., Waterville, Maine [11].
*Morton, Dr. S. G., Philadelphia, Pennsylvania [1].
Munger, George G., Rochester, New York [10].
Munroe, Rev. Nathan, Bradford, Massachusetts [6].
Murray, Prof. David, New Brunswick, New Jersey [11].
Myers, Gustavus A., Richmond, Virginia [11].

## N.

Nason, Prof. Henry B., Beloit, Wisconsin [13].
Nelson, Rev. Cleland K., Annapolis, Maryland [12].
Newberry, Prof. J. S., New York, New York [5].
Newcomb, Simon, Washington, District of Columbia [13].
*Newton, Rev. E. H., Cambridge, New York [1].
Newton, Prof. Hubert A., New Haven, Connecticut [6]
Newton, John, Orange Hill, Washington Co., Florida [7].
Newton, Prof. Robert S., New York, New York [15].
Nichols, Dr. James R., Haverhill, Massachusetts [7].
*Nicollett, J. N., Washington, District of Columbia [1].
Nolen, George A., New Haven, Connecticut [13].
Norton, Edward, Farmington, Connecticut [13].
*Norton, Prof. J. P., New Haven, Connecticut [1].
Norton, Prof. W. A., New Haven, Connecticut [6].
Nye, Rev. A. H., Buffalo, New York [15]

## O.

*Oakes, William, Ipswich, Massachusetts [1].
Oliver, James Edward, Lynn, Massachusetts [7].
*Olmsted, Alexander F., New Haven, Connecticut [4].
*Olmsted, Prof. Denison, New Haven, Connecticut [1].
*Olmsted, Denison, Jr., New Haven, Connecticut [1].
Ordway, John M., Providence, Rhode Island [9].

## P.

Paine, Cyrus F., Rochester, New York [12].
Painter, Minshall, Lima, Delaware Co., Pennsylvania [7].
Palmer, Everard, Buffalo, New York [15].
Parker, Rev. Henry E., Concord, New Hampshire [11].
*Parkman, Dr. Samuel, Boston, Massachusetts [1].
Parvin, Theodore S., Iowa City, Iowa [7].
Peck, Prof. William G., New York, New York [13].
Peirce, Prof. Benjamin, Cambridge, Massachusetts [1].
Peirce, James M., Cambridge, Massachusetts [11].
Perkins, Prof. George R., Utica, New York [1].

Perkins, Prof. Maurice, Schenectady, New York [15].
*Perry, Com. M. C., New York, New York [10].
Peters, Dr. C. H. F., Clinton, New York [9].
Phelps, Almira L., Baltimore, Maryland [13].
Phelps, Charles E., Baltimore, Maryland [13].
Pierce, Henry M., New York, New York [15].
Pierrepont, H. E., Brooklyn, New York [14].
Pitcher, Dr. Zina, Detroit, Michigan [1].
Plant, I. C., Macon, Georgia [3].
*Plumb, Dr. Ovid, Salisbury, Connecticut [9].
Poole, Henry W., Boston, Massachusetts [14].
Pope, Prof. Charles A., St. Louis, Missouri [12].
Porter, Prof. Charles H., Albany, New York [13].
Porter, Charles T., New York, New York [13].
Porter, Prof. John A., New Haven, Connecticut [14].
Porter, Prof. Thomas C., Lancaster, Pennsylvania [12].
Pourtales, L. F., Washington, District of Columbia [1].
Powell, Samuel, Philadelphia, Pennsylvania [13].
Prescott, Dr. William, Concord, New Hampshire [1].
Prince, W. R., Flushing, Long Island [10].
Pruyn, J. V. L., Albany, New York [1].
Pugh, Evan, Centre Co., Pennsylvania [14].

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Quincy, Edmund, Jr., Dedham, Massachusetts [11].

## R.

Rankin, Rev. Alexander T., Buffalo, New York [15].
Ranney, Orville W., Buffalo, New York [15].
Raymond, R. W., New York, New York [15].
Redfield, Charles B., Albany, New York [11].
Redfield, John H., Philadelphia, Pennsylvania [1].
*Redfield, William C., New York, New York [1].
Reed, Lyman, Baltimore, Maryland [12].
Resor, Jacob, Cincinnati, Ohio [8].
Rice, Clinton, New York, New York [7].
Richardson, Dr. Horace, Boston, Massachusetts [12].
Ritchie, E. S., Boston, Massachusetts [10].

Robb, Prof. James, Frederickton, New Brunswick [4].
Robertson, Thomas D., Rockford, Illinois [10].
Robinson, Coleman T., Buffalo, New York [15].
Robinson, Rev. George C., Cincinnati, Ohio [13].
Rochester, Dr. Thomas F., Buffalo, New York [15].
Rockwell, Prof. Alfred P., New Haven, Connecticut [10].
Rockwell, John, La Salle, Illinois [11].
*Rockwell, John A., Norwich, Connecticut [10].
Rodman, William M., Providence, Rhode Island [9].
Rogers, Prof. Fairman, Philadelphia, Pennsylvania [11].
*Rogers, Prof. James B., Philadelphia, Pennsylvania [1].
Rogers, Prof. W. A., Alfred, New York [15].
Rogers, Prof. W. B., Boston, Massachusetts [1].
Rood, Prof. O. N., New York, New York [14].
Roosevelt, Clinton, New York, New York [11].
Root, Prof. O., Clinton, New York [13].
Ruggles, Prof. William, Washington, District of Columbia [8].
Rumsey, Bronson C., Buffalo, New York [15].
Rumsey, Dexter P., Buffalo, New York [15].
Runkle, J. D., Dedham, Massachusetts [2].
Russell, Andrew, Ottawa, Canada West [11].
Rutherford, Louis M., Newport, Rhode Island [13].

## S.

Safford, Prof. J. M., Nashville, Tennessee [6].
Safford, Truman H., Chicago, Illinois [13].
Sanborn, Francis G., Andover, Massachusetts [13].
Sargent, Rufus, Auburn, New York [10].
Savage, Thomas S., Pass Christian, Mississippi [10].
Sawyer, A. W., Acadia College, Nova Scotia [13].
Scarborough, George, Sumner, Kansas [2].
Schaff, Rev. Philip, Mercersburg, Pennsylvania [12].
Schanck, Prof. J. Stillwell, Princeton, New Jersey [4].
Schofield, Prof. J. M., St. Louis, Missouri [13].
Schott, Arthur C. V., Georgetown, District of Columbia [8].
Schott, Charles A., Washington, District of Columbia [8].
Scudder, Samuel H., Boston, Massachusetts [13].
Sellstedt, Laurentius G., Buffalo, New York [15].
Serrell, Edward W., Greenefield, Massachusetts [13].

Seward, William H., Auburn, New York [1].
Sexton, Jason, Buffalo, New York [15].
Seymour, M. H., Montreal, Canada [11].
Shaefer, P. W., Pottsville, Pennsylvania [4].
Shane, J. D., Cincinnati, Ohio [7].
Sheldon, D. H., St. Louis, Missouri [10].
Sherwood, Albert, Buffalo, New York [15].
Sias, Solomon, Auburndale, Massachusetts [10].
Sill, Elisha N., Cuyahoga Falls, Ohio [6].
Silliman, Prof. Benjamin, New Haven, Connecticut [1].
Silliman, Prof. Benjamin, Jr., New Haven, Connecticut [1].
Sillsbee, E. A., Salem, Massachusetts [14].
Skinner, John B., Buffalo, New York [15].
Slack, J. H., Philadelphia, Pennsylvania [12].
Smallwood, Prof. Charles, St. Martin, Isle Jesus, C. E. [7].
Smith, A. D., Providence, Rhode Island [14].
Smith, Prof. Augustus W., Annapolis, Maryland [4].
*Smith, J. V., Cincinnati, Ohio [5].
Smith, James Y., Providence, Rhode Island [9].
*Smith, Dr. Lyndon A., Newark, New Jersey [9].
Snell, Prof. Eben S., Amherst, Massachusetts [2].
Snow, Dr. Edwin M., Providence, Rhode Island [9].
*Sparks, Jared, Cambridge, Massachusetts [2].
Spencer, Charles A., Buffalo, New York [14].
Spring, Dr. Charles H., Boston, Massachusetts [13].
Squier, George L., Buffalo, New York [15].
Stanard, Benjamin A., Cleveland, Ohio [6].
Starr, William, Ceresco, Wisconsin [10].
Stearns, Josiah A., Boston, Massachusetts [10].
Stearns, Prof. William F., Oxford, Mississippi [13].
Steele, Oliver G., Buffalo, New York [15].
Steiner, Dr. Lewis H., Frederick City, Maryland [7].
Sterling, Prof. J. W., Madison, Wisconsin [13].
Stevenson, Charles L., Charlestown, Massachusetts [14].
Stewart, Prof. William M., Clarksville, Tennessee [7].
Stewart, William W., Buffalo, New York [15].
Stimpson, William, Chicago, Illinois [12].
Stone, Rev. Edwin M., Providence, Rhode Island [9].

Storer, Dr. D. H., Boston, Massachusetts [1].
Storer, Prof. Frank H., Boston, Massachusetts [13].
Sutherland, Prof. William, Montreal, Canada [6].
Swallow, Prof. G. C., Columbia, Missouri [10].
Swinburne, John, Albany, New York [6].

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*Taylor, Richard C., Philadelphia, Pennsylvania [1].
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Thomas, Calvin F. S., Buffalo, New York [15].
Thomas, William A., Kingston, Massachusetts [10].
Thompson, Dr. Alexander, Aurora, New York [6].
Thompson, Aaron R., New York, New York [1].
Thompson, H. C., Chapel Hill, North Carolina [13].
*Thompson, Rev. Z., Burlington, Vermont [1].
*Thurber, Isaac, Providence, Rhode Island [9].
Tillman, Prof. S. D., New York, New York [15].
Tingley, J., Meadville, Pennsylvania [15].
Tingley, Prof. Joseph, Greencastle, Indiana [14].
Tolles, Robert B., Canastota, New York [15].
Torrey, Dr. John, New York, New York [1].
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Townsend, Hon. Franklin, Albany, New York [4].
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Trowbridge, Prof. W. P., New York, New York [10].
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Turner, Dr. Henry E., Newport, Rhode Island [14].
Tuthill, Dr. Franklin, New York, New York [8].
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Tyler, P. B., Springfield, Massachusetts [13].
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Tyson, Philip T., Baltimore, Maryland [12].

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Van Vleck, Prof. J. M., Middletown, Connecticut [9].
Vaux, William S., Philadelphia, Pennsylvania [1].
Viele, Henry K., Buffalo, New York [15].
Vose, George L., Paris Hill, Maine [15].
Vought, John H., Buffalo, New York [15].

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Wadsworth, James S., Genesee, New York [2].
Wagner, Tobias, Philadelphia, Pennsylvania [9].
Walker, Joseph, Oxford, New York [10].
Wales, William, Fort Lee, New York [15].
*Walker, Sears C., Washington, D. C. [1].
*Walker, Hon. Timothy, Cincinnati, Ohio [4].
Ward, Henry A., Rochester, New York [13].
Warner, H. G., Rochester, New York [11].
Warren, G. K., U. S. A., Washington, D. C. [12].
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Watson, Prof. William, Cambridge, Massachusetts [12].
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*Webster, Dr. J. W., Cambridge, Massachusetts [1].
*Webster, M. H., Albany, New York [1].
Webster, Nathan B., Portsmouth, Virginia [7].
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Wheildon, W. W., Charlestown, Massachusetts [13].
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Whitney, H. H., Montreal, Canada [11].
Whitney, J. D., Northampton, Massachusetts [1].
Whitney, Prof. William D., New Haven, Connecticut [12].
Whittlesey, Charles, Cleveland, Ohio [1].
Whittlesey, Charles C., St. Louis, Missouri [11].
Wilkes, Com. Charles, U. S. N., Washington, D. C. [1].
Willard, Emma, Troy, New York [15].
Williams, Dr. Henry W., Boston, Massachusetts [11].
Williams, Matthew, M. D., Syracuse, New York [13].
Williams, Thomas H., Portsmouth, Virginia [12].
Williamson, R. S., U. S. A., San Francisco, Cal. [12].
Willmarth, A. F., New York, New York [15].
Wilson. Prof. Daniel, Toronto, Canada [10].
Winchell, Prof. Alexander, Ann Arbor, Michigan [3].
Woodbridge, George A., Nashville, Tennessee [10].
*Woodbury, Hon. L., Portsmouth, New Hampshire [1].
Worthen, A. H., Springfield, Illinois [5].
Wright, A. W., New Haven, Connecticut [14].
Wright, Chauncey, Cambridge, Massachusetts [9].
*Wright, Dr. John, Troy, New York [1].
Wurtele, Rev. Louis C., Lennoxville, Canada East [11].
Wurtz, Prof. Henry, New York, New York [10].
Wyckoff, Dr. C. C., Buffalo, New York [15].
Wynne, Dr. James, New York, New York [14].
Wynne, Thomas H., Richmond, Virginia [8].

## Y.

Youmans, E. L., Saratoga Springs, New York [6].
*Young, Prof. Ira, Hanover, New Hampshire [7].

The above list contains six hundred and thirty-three names, of which one hundred are of deceased members.

# MEMBERS ELECTED

AT

# THE BUFFALO MEETING.*

*Adelberg, Dr. J., New York, New York.
Allen, Mary B., Rochester, New York.

*Barry, William F., Buffalo, New York.
Bird, William A., Buffalo, New York.
Blake, Eli W., Burlington, Vermont.
Bradish, Alvah, Fredonia, New York.
Bradley, L., Jersey City, New Jersey.
Brayley, James, Buffalo, New York.
*Breed, Frederick W., Buffalo, New York.
Buck, C. E., New York, New York.
‡Bush, Myron P., Buffalo, New York.

Caldwell, Stephen D., Fredonia, N. Y.
Case, Leonard, Cleveland, Ohio.
Cattell, William C., Easton, Penn.
Chester, Albert H., New York, N. Y.
Chester, Albert T., Buffalo, New York.
Clapp, Almon M., Buffalo, New York.
*Clark, Walter, Buffalo, New York.
Clinton, George W., Buffalo, New York.
Cochran, D. H., Brooklyn, New York.
Craig, B. F., Washington, D. C.
*Credner, Herman, New York, New York.

*Davis, N. K., Marion, Alabama.
*Day, David N., Buffalo, New York.
Dean, George W., Fall River, Mass.
Dobbins, David B., Buffalo, New York.
*Dole, Thomas D., Buffalo, New York.
Dorr, E. P., Buffalo, New York.

Evans, Charles W., Buffalo, New York.

†Farnham, Thomas, Buffalo, New York.
†Fish, George T., Buffalo, New York.
Forbush, E. B., Buffalo, New York.
*French, J. R., Lima, New York.

Gay, C. C. F., Buffalo, New York.
*Gleason, George U., Buffalo, New York.
Grote, Augustus R., Buffalo, New York.

Harvey, Charles W., Buffalo, New York.
Harvey, Leon F., Buffalo, New York.
Hayes, George E., Buffalo, New York.
Herzer, Herman, Delaware, Ohio.
*Hewitt, A. S., New York, New York.
*Hosmer, George W., Buffalo, New York.
†Hough, G. W., Albany, New York.
Howland, Theodore, Buffalo, New York.

*Ives, William, Buffalo, New York.

†Kimball, J. P., New York, New York.

†Lattimore, S. A., Lima, New York.
Lee, John R., Buffalo, New York.
†Leonard, A. M., Lockport, New York.
Letchworth, William P., Portage, N. Y.
†Little, George, Oakland, Mississippi.
Lothrop, Joshua R., Buffalo, New York.
*Lyle, J. N., Marietta, Ohio.
Lyman, B. S., Philadelphia, Penn.

Marsh, O. C., New Haven, Connecticut.
Marshall, Charles D., Buffalo, New York.
Marshall, Orasmus H., Buffalo, N. Y.
Meade, George G., Philadelphia, Penn.
*Murray, Alexander, United States Navy.

Newton, Robert S., New York, New York.
†Nichols, A. P., Buffalo, New York.
*Norton, Charles D., Buffalo, New York.
†Nye, A. H., Buffalo, New York.

Palmer, Everard, Buffalo, New York.

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* Those marked with an asterisk have not responded. ‡ Declines.

† Those marked thus (†) have accepted and paid the assessment, without signing the constitution.

*Parmalee, D. D., New York, New York.
Pease, Francis S., Buffalo, New York.
Perkins, Maurice, Schenectady, N. Y.
†Pierce, Henry M., New York, New York.

Rankin, Alexander T., Buffalo, N. Y.
Ranney, Orville W., Buffalo, New York.
†Raymond, R. W., New York, New York.
Robinson, Coleman T., Buffalo, N. Y.
†Rochester, Thomas F., Buffalo, N. Y.
Rogers, W. A., Alfred, New York.
†Rumsey, Bronson C., Buffalo, New York.
†Rumsey, Dexter P., Buffalo, New York.
*Saxton, Rufus, Buffalo, New York.
†Sellstedt, Laurentius G., Buffalo, N. Y.
Sexton, Jason, Buffalo, New York.
*Seymour, Horatio, Buffalo, New York.
†Sherwood, Albert, Buffalo, New York.
Skinner, John B., Buffalo, New York.
†Spencer, Charles A., Buffalo, New York.
*Sprague, Henry S., Buffalo, New York.
†Squier, George L., Buffalo, New York.
Steele, Oliver G., Buffalo, New York.
Stewart, William W., Buffalo, New York.
*Strong, John C., Buffalo, New York.
Sweeney, James, Buffalo, New York.
*Taft, C. H., Buffalo, New York.
*Teller, Daniel W., New York, N. Y.
Thomas, Calvin F. S., Buffalo, N. Y.
Tillman, S. D., New York, New York.
†Tingley, J., Meadville, Pennsylvania.
†Tolles, Robert B., Canastota, New York.
*Trippel, Alexander, New York, N. Y.

*Upham, George U., Buffalo, New York. ?

Viele, Henry K., Buffalo, New York.
†Vose, George L., Paris Hill, Maine.
†Vought, John H., Buffalo, New York.

*Wadsworth, Charles F. Buffalo, N. Y.
†Wales, William, Fort Lee, New York.
*Wells, Chandler D., Buffalo, New York.
*Wells, David A., Norwich, Connecticut.
Wenz, J., New Orleans, Louisiana.
†Willard, Emma, Troy, New York.
*Williams, Charles H., Buffalo, New York.
*Williams, Gibson T., Buffalo, New York.
†Wilmarth, A. F., New York, New York.
*Winne, Charles, Buffalo, New York.
*Woodward, John L. J., Washington, D. C.
Wyckoff, C. C., Buffalo, New York.

# PROCEEDINGS

OF THE

# BUFFALO MEETING, 1866.

## COMMUNICATIONS.

## PART I.

## A. MATHEMATICS, PHYSICS, AND CHEMISTRY.

### I. ASTRONOMY AND METEOROLOGY.

### 1. ON THE PHYSICAL CONDITION OF THE SUN'S SURFACE, AND THE MOTION OF THE SOLAR SPOTS. By Prof. ELIAS LOOMIS, of New Haven, Conn.

THE object of this paper is briefly to describe the results which have been rendered probable by recent observations, and to state some conclusions which seem to me to flow from them.

The researches of Kirchhoff have rendered it highly probable that the elements of which the sun is composed are, to a great extent, the same as those found upon the earth. The existence of iron, nickel, calcium, sodium, chromium, and magnesium, in the sun's atmosphere, is considered as proved. Now, the density of the sun is only one fourth that of the earth, while the force of gravity is twenty-eight times its force upon the surface of the earth. We cannot, then, suppose that any considerable part of the sun's mass is in the condition of a solid or even a liquid body. Moreover, the most refractory substances, iron and nickel, exist upon the sun in the state of elastic vapor. The temperature of the sun's surface is therefore extremely elevated; far beyond the heat of terrestrial volcanoes. The movements of the solar spots indicate that the sun's mass is fluid to a great depth; and we cannot suppose that the black nucleus of a solar spot is the obscure solid mass of the sun.

It is possible that near the centre of the sun there may exist a portion which has been reduced to the liquid or even the solid condition; but it is probable that the principal part of the sun's volume consists of matter in the gaseous or semi-gaseous condition. It is conceivable that under the immense pressure which exists upon the sun, the mobility of many gases may be somewhat impaired; and that they may be reduced to a condition intermediate between that of a perfect gas and a liquid. Such a condition I designate by the term semi-gaseous.

The visible portion of the sun, which we call its photosphere, consists of matter in a state analogous to that of aqueous vapor in terrestrial clouds; that is, in the condition of a precipitate suspended in a transparent atmosphere. This photosphere is not only intensely luminous, but intensely hot; and the thermoscope indicates that it radiates more heat than the solar spots; but this does not prove that the photosphere is really hotter than the nucleus of a solar spot, for the experiments of Tyndall prove that gases radiate heat more feebly than solids of the same temperature. The matter of the photosphere probably consists of particles precipitated in consequence of their being cooled by radiation; and, if these particles could recover the more elevated temperature of the interior portion of the sun, they would return to the elastic and invisible state of vapor.

The sun's gaseous envelope extends far beyond the photosphere. During total eclipses, we observe flame-like protuberances rising to a height of 80,000 miles above the surface of the sun, which require us to admit the existence of bodies analogous to clouds floating at great elevations in an atmosphere; and, if the extent of the solar atmosphere, compared with the height of the visible clouds, corresponds with what exists upon the earth, we must conclude that the solar atmosphere extends at least a million of miles beyond his surface.

In order to account for the penumbra of a solar spot, it is not necessary to admit the existence of a second stratum of clouds distinct from the photosphere. The penumbra appears to be formed of filaments of photospheric-light, converging towards the centre of the nucleus;

each of the filaments having the same light as the photosphere; and the sombre tint results from the interstices between the luminous streaks; as in a steel engraving, shades are produced by dark lines separated by white interstices.

That the penumbra is a cavity is proved by the fact, which has been often observed, that when spots of a regular form approach the sun's limb, they lose the penumbra on the side which is towards the sun's centre, while the penumbra remains on the side which is towards the sun's limb; and the depth of this cavity has been repeatedly computed to be about one-third of the earth's radius.

The convergence of the luminous streaks of the penumbra towards the centre of the spot indicates the existence of currents flowing towards the centre. These converging currents probably meet an ascending current of the heated atmosphere, by contact with which the matter of the photosphere is dissolved and becomes non-luminous.

What cause can be assigned for the movements which are observed in the atmospheric envelope of the sun? Such movements would result from unequal temperature in different parts of the sun's surface. But why should not the temperature of the sun's surface be uniform throughout?

The heat of the sun must be continually dissipated by radiation. If this radiation is more obstructed in some regions than in others, heat must accumulate in such places. Now, the phenomena observed during total eclipses indicate in the sun's atmosphere the existence of large masses, analogous to terrestrial clouds. Wherever these clouds prevail, the free radiation of heat from the sun must be obstructed, and heat must rapidly accumulate. The solar atmosphere tends to move towards the heated centres, and this must be accompanied by an upward motion at the centre. The heated air, thus ascending, partly dissolves and partly divides the matter of the photosphere, causing it to heap up in a ring around the opening, producing thus around the margin of the penumbra the appearance of a ring of light more intense than the general photosphere.

It has long been known that the spots have a relative motion upon the sun's surface. This motion is sometimes *towards* the equator, and sometimes *from* the equator; sometimes towards the east, and sometimes towards the west. We have assigned a cause for this motion.

Let us consider the consequences which should result from such a motion, combined with the rotation of the sun upon an axis.

If a spot on the north side of the solar equator receives an impulse towards the north, then, since it must retain the westerly motion it had at starting, it will have a relative motion towards the west as well as towards the north; that is, its path on the sun's surface will be towards the north-west; and its angular velocity of rotation will be *greater* than if it had remained stationary upon the sun's surface.

If the spot had received an impulse *towards* the equator, then, since it is moving towards a region which has a greater velocity of motion westward, it will have a relative motion eastward; that is, the path of the spot will be towards the south-east, and its angular velocity of rotation will be *less* than if it had remained stationary upon the sun's surface. In each case, the angular velocity of rotation of a solar spot should be *least* at the equator, and should increase as we recede from the equator. Now, observation informs us that the reverse is the case. The angular velocity of rotation is greatest at the equator, and diminishes towards either pole. Mr. Carrington has found that the daily angular velocity of rotation of the spots may be expressed by the formula:

$$865' - 165 \text{ sin. } \tfrac{7}{4} \text{ lat.}$$

According to this formula, the angular motion of points on the sun's surface in different latitudes is as shown in column second of the following table; and the absolute velocity in miles per hour, as shown in the last column.

ROTATION OF POINTS ON THE SUN'S SURFACE.

| | | |
|---|---|---|
| Lat. 0° | 865′.0 per day, | 4655 miles per hour. |
| “ 5 | 862 .7 “ | 4625 “ |
| “ 10 | 857 .3 “ | 4543 “ |
| “ 15 | 849 .5 “ | 4416 “ |
| “ 20 | 839 .8 “ | 4246 “ |
| “ 25 | 828 .5 “ | 4041 “ |
| “ 30 | 815 .9 “ | 3802 “ |

What conclusion must we derive from these observed facts, and how can they be explained?

The interior portion of the earth is known to be denser than the exterior crust. Let us suppose, in like manner, that the denser material of the sun has mainly subsided to the interior. We may suppose the entire body of the sun to be in the gaseous or semi-gaseous condition, with the denser elements mainly collected at the centre; or we may suppose the central portion to be reduced to the liquid or even the solid condition,—the liquid or solid portion constituting but a small part of the sun's volume. In either case, the denser particles, subsiding towards the centre, would have a greater angular velocity of rotation; that is, the central portion of the sun would rotate more rapidly than the exterior gaseous portion. Conceive then a sphere 400,000 miles in diameter (either solid or liquid, or composed of gases in a highly condensed state), rotating with considerable velocity, and surrounded by a gaseous envelope, 800,000 miles in diameter, and rotating with a less angular velocity. The central sphere would communicate something of its motion to the superincumbent envelope in the neighborhood of its equator; but would produce little effect in the polar regions, so that upon the outer surface of such a gaseous envelope the angular velocity of rotation would be most rapid at the equator, and would diminish towards either pole.

This hypothesis enables us thus to explain the phenomena observed upon the sun's surface, and increases the probability of the hypothesis that the matter of the sun exists in the gaseous condition to at least a considerable depth; a depth probably not less than half the sun's radius.

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## 2. On the Period of Algol. By Prof. Elias Loomis, of New Haven, Conn.

In 1854, Argelander published (Astronom. Nachricht., xxxix. 291) a discussion of all the observations which had been made up to that date, for determining the period of the variations in the light of Algol. These observations were 168 in number, and he determined the length of a single period for several different dates from 1784 to 1854, from which it appears that during that interval the period of Algol had diminished about six seconds. In 1857, Argelander published (Astron. Nachr. xlv. 103), the results of thirty-four additional observations which indicated a continuous diminution of period, amounting to over seven seconds since 1784.

In 1859, Mr. Masterman published (London Astronom. Journal, v. 190) the results of twenty-one observations, which compared with Argelander's last result indicated that the period of Algol was *no longer diminishing.*

During the past season I have observed a few minima of Algol at New Haven, and have combined them with such European observations as have been published in the Astronomische Nachrichten. Taking ten of the observations, which were made under the most favorable circumstances, and correcting them for the light equation, they give for the mean Paris time of minimum, 1865, Oct. 21, $15^h$ $10^m$ $20.4^s$, which compared with Masterman's result for 1859, gives a mean period of $2^d$ $20^h$ $48^m$ $54.5^s$, showing an increase of three seconds above the minimum which occurred about 1855.

The following table shows the results of the later observations here referred to.

| Epoch. | Paris mean time of Minimum. | No. of Obs. | Observer. |
|---|---|---|---|
| + 6976 | 1854, Oct. 8, $5^h$ $30^m$ $27.0^s$ | 24 | Argelander. |
| + 7142 | 1856, Jan. 27, 4 40 38. 1 | 34 | Argelander. |
| + 7516 | 1859, Jan. 3, 13 17 13. 4 | 21 | Masterman. |
| + 8382 | 1865, Oct. 21, 15 10 20. 4 | 10 | Loomis. |

The following table shows the intervals between the preceding dates, together with the number of periods and the mean duration of a single period.

| Periods. | Intervals. | Mean Period. |
|---|---|---|
| 166 | $475^d$ $23^h$ $10^m$ $11.1^s$. | $2^d$ $20^h$ $48^m$ $51.5^s$ |
| 374 | 1072 8 36 35.3. | 2 20 48 52.1. |
| 866 | 2483 1 53 7.0. | 2 20 48 54.5. |

The following are the mean periods of Algol determined for different dates, since the first observations in 1784.

| | |
|---|---|
| 1784, May 27, | $2^d$ $20^h$ $48^m$ $59.^s4$ |
| 1793, July 11, | " 58. 4 |
| 1818, April 12, | " 58. 2 |
| 1842, Sept. 19, | " 55. 2 |
| 1849, June 17, | " 54. 9 |
| 1851, Dec. 7, | $2^d$ $20^h$ $48^m$ 53. 2 |
| 1855, June 3, | " 51. 5 |
| 1857, July 17, | " 52. 1 |
| 1862, May 29, | " 54. 5 |

For two and a half days Algol remains invariably of the brightness of β Cassiopeæ; it then declines and attains its least brightness in about three and a half hours, and in about three and a half hours more it attains again to the brightness of β Cassiopeæ; that is, for nearly nine-tenths of the whole time the light of Algol remains unimpaired.

We cannot ascribe these variations of brightness to the flattened form of Algol, or to dark spots upon its surface, for in such a case the duration of greatest brightness could not exceed one half of the entire period.

If we ascribe these variations of light to a dark opaque body revolving about Algol, and suppose the mass of Algol to be equal to that of our sun, a period of $2^d\ 20^h$ would imply a distance of nearly four millions of miles; that is, the circumference of its orbit must be nearly twenty-four millions of miles. In order that this body may interfere with the light of Algol during seven hours, if we suppose the diameter of Algol to be equal to that of our sun, the diameter of the opaque body must be twice as great, if it passed centrally over Algol, in which case the light of Algol would be totally eclipsed for about two hours. In order to explain the merely partial loss of light, we must suppose that the opaque body does not pass centrally over Algol, and must therefore assign to it a still larger diameter, which would make its volume more than ten times that of Algol. Algol thus becomes an unimportant satellite to an obscure central body of enormous magnitude; a supposition so improbable that it is presumed no one will be disposed to accept it.

All the observed phenomena may be explained by supposing a nebulous body of irregular form, with a length of nearly two millions of miles, or a group of small solid bodies of the same extent, revolving about Algol as a centre. The inequalities observed in the changes of Algol from maximum to minimum may be ascribed to irregularities in the form of the nebulous body; and the slight diminution in the period of Algol from 1784 to 1855, and the slight increase since 1855, may be accounted for by supposing, *not* a change in the absolute time of revolution of the nebulous body, but simply a change of position of the major axis of the orbit with reference to a line from the earth to Algol.

If the explanation here assigned is the true one, we should expect that the bright and dark lines of the spectrum of Algol would undergo a decided change at the time of its diminished light.

## 3. ON THE THEORY OF METEORS. By Prof. DANIEL KIRKWOOD, of Canonsburg, Penn.

IT is now well known that much greater variety obtains in the structure of the solar system than was formerly supposed. This is true not only in regard to the magnitudes and densities of the bodies composing it, but also in respect to the forms of their orbits. Before the discovery of the asteroids, the smallest planetary bodies known were the interior satellites of Saturn, supposed to have a diameter of about five hundred miles. But the estimated diameters of the planets between Mars and Jupiter vary from two hundred and sixty to fifteen miles; and, with sufficient optical power an indefinite number, still more minute, would doubtless be detected. In orbits nearly circular, however, bodies so extremely small could not become known to us, unless their mean distances were nearly the same with that of the earth. But with eccentricities equal to those of the comets of short period, the orbits of all having their mean distances included between those of Venus and Jupiter, would intersect, or nearly intersect, the earth's path. Now, in the case of both asteroids and comets, the smallest are the most numerous; and, as this doubtless continues below the limit of telescopic discovery, the earth ought to encounter such bodies in its annual motion. IT ACTUALLY DOES SO. The number of *cometoids* thus encountered, in the form of *meteoric stones*, *fire-balls*, and *shooting stars*, in the course of a single year, amounts to many millions. The extremely minute, and such as consist of matter in the gaseous form, are consumed or dissipated in the upper regions of the atmosphere; no deposit from ordinary shooting stars having ever been known to reach the earth's surface. But there is probably great variety in the physical constitution of the bodies encountered; and, though comparatively few contain a sufficient amount of matter in the solid form to reach the surface of our planet, scarcely a year passes without the fall of meteoric stones in some part of the earth, either singly or in clusters. Now, when we consider how small a proportion of the whole number are probably observed, it is obvious that the actual occurrence of the phenomenon can be by no means rare.

The most probable inference from a comparison of the facts known in regard to comets, shooting stars, fire-balls, and meteoric stones, is that they are bodies of the same nature, and perhaps of similar origin; differing from each other mainly in the accidents of magnitude and density. The amount of matter under these various forms within the limits of the solar system is doubtless immense. Besides the meteoric rings of August and November, several others are now well known. It is worthy of remark, moreover, that three of the dates specified by Mr. Greg as *aerolite* epochs are coincident with those of shooting stars; namely, February 15th–19th, July 26th, and December 13th. The whole number of exhibitions enumerated in Quetelet's Catalogue[1] is 315. In eighty-two instances the day of the month on which the phenomenon occurred is not specified. Nearly two-thirds of the remainder belong to established epochs, and the periodicity of others will perhaps yet be discovered. But reasons are not wanting for believing that our system is traversed by numerous meteoric streams besides those which actually intersect the earth's orbit. The asteroid region between Mars and Jupiter is doubtless such an annulus. The Zodiacal Light is probably a dense meteoric ring, or rather, perhaps, a number of rings. We speak of it as *dense* in comparison with others which are invisible except by the ignition of their particles in passing through the atmosphere.

Of the various theories which have been proposed to account for the origin of solar heat, perhaps the most probable is that (advocated by Mayer, Prof. William Thomson, and others), which ascribes it to the fall of meteoric matter. According to this hypothesis, the Zodiacal Light consists of meteoric masses revolving round the sun in gradually converging orbits. The inner portions of this immense "tornado" are resisted in their motion by the solar atmosphere, and hence are being constantly precipitated upon the sun's surface. The orbital motion thus arrested is converted into heat. The present paper is designed to extend this meteoric theory to a number of phenomena that have hitherto received no satisfactory explanation.

## I. VARIABLE AND TEMPORARY STARS.

No theory as to the origin of the sun's light and heat would seem to be admissible unless applicable also to the sidereal systems. Will the meteoric theory explain the phenomena of variable and temporary stars?

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[1] Physique du Globe, chapitre IV.

"It may be remarked respecting variable stars, that, in passing through their successive phases, they are subject to sensible irregularities, which have not hitherto been reduced to fixed laws. In general they do not always attain the same maximum brightness, their fluctuations being in some cases very considerable. Thus, according to Argelander, the variable star in *Corona Borealis*, which Pigott discovered in 1795, exhibits on some occasions such feeble changes of brightness, that it is almost impossible to distinguish the maxima from the minima by the naked eye; but after it has completed several of its cycles in this manner, its fluctuations all at once become so considerable that in some instances it totally disappears. It has been found, moreover, that the light of variable stars does not increase and diminish symmetrically on each side of the maximum, nor are the successive intervals between the maxima exactly equal to each other."[1]

Of the numerous hypotheses hitherto proposed to account for these phenomena we believe none can be found to include and harmonize all the facts of observation. The theories of Herschel and Maupertius fail to explain the irregularity in some of the periods of variation; while those of Newton and Dunn afford no explanation of the periodicity itself. But let us suppose that among the fixed stars some have atmospheres of great extent, as was probably the case with the sun at a remote epoch in its history. Let us also suppose the existence of nebulous rings, like those of our own system, moving in orbits so elliptical that in their perihelia they pass through the atmospheric envelopes of the central stars. Such meteoric rings of varying density, like those revolving about the sun, would evidently produce the phenomena of variable stars. The resisting medium through which they pass in perihelion must gradually contract their orbits, or, in other words, diminish the intervals between consecutive maxima. Such a shortening of the period is now well established in the case of *Algol*. Again, if a ring be influenced by planetary perturbations, the period will be variable, like that of *Mira Ceti*. A change, moreover, in the perihelion distance will account for the occasional increase or diminution of the apparent magnitude at the different maxima of the same star. But how are we to account for the variations of brightness observed in a number of stars where no order or periodicity in the variation has as yet been discovered? It is easy to perceive that either a single nebulous ring with more than one *hiatus*, or several rings about the same star, may produce phenomena of the character described. Finally, if the matter of an elliptic ring should accumulate in a single mass, so as to occupy a comparatively small arc, its passage through perihelion might produce the phenomenon of a so-called temporary star.

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[1] Grant's History of Physical Astronomy, p. 541.

Recent researches relating to nebulæ seem in some measure confirmatory of the view here presented. These observations have shown, (1) a change of position in some of these objects, rendering it probable that in certain cases they are not more distant than fixed stars visible to the naked eye, and (2) a variation in the brilliancy of many small stars situated in the great nebula of Orion, and also the existence of numerous masses of nebulous matter in the form of tufts apparently attached to stars;—facts regarded as indicative of a physical connection between the stars and nebulæ.[1]

## II. The Diminution of Mercury's Mean Motion.

From a comparison of the ancient and modern observations of Mercury, Leverrier has found that the planet's mean motion has sensibly diminished,[2] as though its distance from the sun had been slightly increased. Now, since the interior planets appear to be moving through the masses of meteoric matter which constitute the Zodiacal Light, it would seem probable that they are receiving from this source much greater accretions of matter than the earth. Mercury's orbit, moreover, is very eccentric; and hence he is beyond his mean distance from the sun during much more than half his period. Probably, therefore, the greater increments of meteoric matter are derived from such portions of the Zodiacal Light as have a longer period than Mercury himself. If so, the obvious tendency would be to diminish slowly the planet's mean motion.

## III. Dark Days.

Several instances are recorded of remarkable obscurations of the sun without any known adequate cause. The transit of a stream or cloud of meteoric asteroids affords the most probable explanation of the phenomenon.

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[1] Gautier's Notice of Recent Researches relating to Nebulæ, American Journal of Science and Arts, Jan. 1863, and March 1864.

[2] Leverrier's *Annales de l'Observatoire*, tome I., p. 38.

## IV. MOTION OF THE APSIDES OF TITAN.

Bessel found the apsides of Titan to have a direct annual motion of 30′ 28″ in longitude on the ecliptic. Assuming that this motion is produced by the disturbing influence of the ring, the great Königsberg astronomer estimated the mass of the latter at $\frac{1}{118}$th, that of Saturn being unity. The following considerations seem sufficient to render the correctness of this determination doubtful; especially as another probable cause may be assigned for the phenomenon: —

1. The mass assigned by Bessel is more than fifty times the sum of the masses of the eight satellites, and indeed nearly equal to the mass of the earth itself. Now, that the ring or rings may be regarded as satellites is universally admitted. But as a general thing the interior members of a system are *smaller* than the more remote. So large a mass, therefore, near the centre of the system would be an exception to the order elsewhere observed.

2. With Bond's estimate of the thickness of the ring, the density corresponding to Bessel's value of the mass is much greater than that of the primary; greater, indeed, than that of any member of the planetary system exterior to Mars.

3. The physical aspect of the rings is not indicative of considerable density. The new or innermost one is semi-transparent. The body of the planet has been faintly seen through it without distortion, showing that the rays of light do not pass through a refracting medium. It is probable, therefore, that the rings consist of meteoric masses in a disintegrated state; those of the innermost being very sparsely scattered; the others of sufficient thickness to prevent the transmission of light, but less compact than would be indicated by Bessel's value of the mass.

On the slightest examination of the Saturnian system, we observe between Rhea and Titan a remarkable chasm in the order of distances of the satellites. This missing term is no less obvious than was that between Mars and Jupiter before the discovery of the asteroids. Now, as in the primary system the zone of small planets occurs just interior to the powerful mass of Jupiter, it seems probable that a similar ring of meteor-asteroids exists within the orbit of Titan, the largest of Saturn's satellites. The disturbing influence of such a mass may account, at least partially, for the phenomenon attributed by Bessel to the attraction of the ring.

## V. Saturn's Rings.

In the meteoric theory, the rings of Saturn consist of an indefinite number of extremely minute asteroids or meteorites. It may also be worthy of remark that the interval between the two bright rings corresponds to the distance at which a satellite would revolve in precisely one-third of the period of Enceladus; — a fact which seems suggestive in regard to the cause of this interval. The portions of the primitive ring which revolved at this distance would always be in conjunction with that satellite in the same parts of the orbit. The disturbing effect would be increased at every conjunction; the orbits of the disturbed particles becoming more and more eccentric until such portions of the meteoric matter would be brought in contact with others at either a greater or less mean distance from the centre.

## VI. Distribution of the Mean Distances of the Asteroids between Mars and Jupiter.

Of the 87 asteroids whose elements have been computed, 69 are included within the limits 2.20 and 2.80. As the difficulty of detection increases with the increase of distance, it would perhaps be premature to attempt any classification of the distances beyond the latter limit. The distribution of those whose mean distances are less than 2.80 is as follows: —

| | | | |
|---|---|---|---|
| between | 2.20 and 2.30 | 6 | minimum. |
| “ | 2.30 and 2.40 | 11 | maximum. |
| “ | 2.40 and 2.50 | 13 | |
| “ | 2.50 and 2.60 | 7 | minimum. |
| “ | 2.60 and 2.70 | 17 | maximum. |
| “ | 2.70 and 2.80 | 15 | |

Two remarkable chasms occur in the order of distances of these bodies, one, between Ariadne (2.2034) and Feronia, (2.2677), the other, between Thetis (2.4733) and Hestia (2.5261). The former includes the distance at which 7 periods of an asteroid would be equal to 2 of

Jupiter; the latter, that at which 3 periods of an asteroid would be equal to 1 of Jupiter. Another decided hiatus is observed between Leto (2.7822) and Polyhymnia (2.8651). This, it will be noticed, corresponds to the distance at which 5 asteroid periods would be equal to 2 of Jupiter. These gaps or chasms may thus be regarded as analogous to those in the ring of Saturn.

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## 4. ON THE DEARBORN OBSERVATORY. By T. H. SAFFORD, of Chicago, Ill.

THIS observatory originated in a movement started some years ago by Prof. Forey, who gave a series of lectures on Astronomy in Chicago, and proposed to the citizens the purchase of a telescope of Mr. Henry Pitts. A committee was appointed to raise subscriptions for the purpose, and Hon. J. Y. Scammon offered the means for the erection of the necessary building. A committee was also appointed to investigate the subject of telescopes, and determined not to purchase the instrument of Mr. Pitts, but to obtain, if possible, that being constructed by Mr. Clarke, of Cambridge, Mass., which had been ordered by President Barnard for the University of Mississippi, but which was lost to its original purchasers by the occurrence of the war. The object-glass for this instrument is the largest in existence, — eighteen and a half inches in diameter. It was procured with some difficulty, and the building to receive it was commenced, and was completed last March. It is built of the limestone common in Chicago, and is situated at the southern extremity of the city. The diameter of the tower is thirty feet, its height ninety-six feet, which is favorable to observations, owing to the greater stillness of the atmosphere. The object-glass of the telescope is of first-class excellence, so that full advantage is got of the aperture. The focal distance of the glass is twenty-three feet.

The subject of observation, with which I have chiefly occupied myself since the telescope was mounted, has been that of the nebulæ. I have found thirty-seven new nebulæ not catalogued by Herschel, and noticed that many of those described by Herschel as very faint appear but slightly faint, showing that the Chicago instrument has great optical power.

## II. ELECTRICITY AND CHEMISTRY.

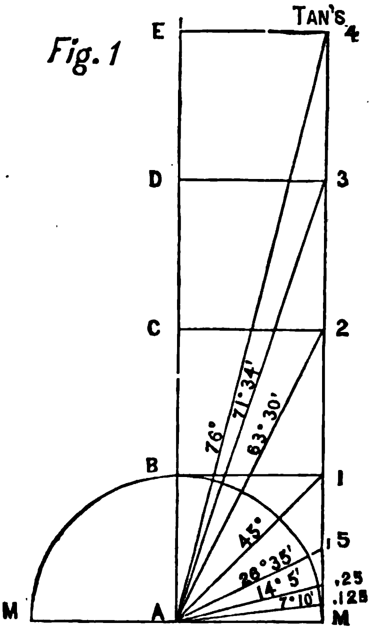
### 1. On the Anthistometer. By Dr. L. Bradley, of New York.

The Rheostat is an instrument for fixing the state and regulating the flow of a current of electricity. It has been employed under different forms by philosophers and professors, to prove theories and establish principles. I have enlarged its field of usefulness in making it a thing of every-day practical utility in business. The improved Rheostat and the improved Tangent Galvanometer here exhibited, taken together, constitute an instrument for conveniently determining and correctly measuring the resistance which conductors of electricity oppose to the free propagation and transmission of a current through them, and the resistance of coils, magnets, batteries, &c. It is a *measure of resistance* to which I have applied the name *Anthistometer*, from the Greek, signifying a measure of resistance.

This instrument I have in constant use; and in my business, in relation to telegraphy, I have made it what the scale-beam or yard-stick is in commerce. I have adopted the practice of measuring and marking the resistance of all the magnets I put upon the market, which enables telegraph superintendents to arrange and adapt their magnets to the several parts of lines so as to secure the greatest economy in their use, which is a matter of very great importance. I make the *rheostat* daily useful also in comparing magnets and ascertaining their relative working qualities.

The subject of a uniform standard of resistance has engaged the attention of electricians considerably, but they have not as yet arrived at anything reliable. Wire of a given number is not only more or less variable in its dimensions, but is also variable in the specific resistance of the metal of which it is composed. The standard unit of resistance of this instrument approximates that of one mile of No. 8 iron wire. It consists of coils of different resistances, from the ¼ mile to 150 miles, which are so connected with switches that any amount of resistance up to 1200 miles can be introduced at pleasure; and the graduated sliding bar subdivides the ¼ of a mile into hundredths of a mile. The true Tangent Galvanometer (Rheometer) measures correctly the strength or actual force of a current in circulation, which it may be demonstrated is directly proportional to the tangent of the angle of deflection. Common galvanometers do not fulfil the requisite condition for this, viz.: that the adventitious force which is sent through the galvanometer coil shall act with the same uniformity upon the needle in all its deviations as the terestrial magnetism does. Where the coil is narrow and the needle long, the inductive influence upon the needle is very great while it is at or near the meridian; but, as it deflects, its extremities pass more and more away from the rays of induction, and consequently its deflections are less and less, so that the tangents of deflection are not at all proportional to the strength of current. To obviate this difficulty, I made a coil of few layers carefully wound, whose width was equal to the length of the needle, but upon trial a difficulty in the opposite direction was manifest. When the needle is on the meridian over such a coil it is under the influence of but few convolutions of the coil wire, but as it deflects more and more, it comes under the influence of more and more of the convolutions, so that the effect, instead of diminishing, as in the former case, is more and more increased. Being now convinced that the truth lay somewhere between the extremes of these experiments, I resolved to find it if possible, and upon a little reflection the expedient was presented of making a compound needle, composed of several pieces or needles of thin flat steel, fixed horizontally upon a light flat ring of metal, and so trimmed as to form a complete circular disc of needles having an agate cup in the centre to rest upon the pivot on which it turns. At each extremity of the meridian light points project to indicate the degrees of deflection. The needles being polarized and balanced upon the pivot

Fig. 1



and placed over the coil, it was found to move with great celerity. This compound circular needle being under the influence of the same number of convolutions of the coil in all its deflections, it would seem, must necessarily fulfil the conditions required as mentioned above.

The Theorem: "*The intensity of currents, as measured by the tangent galvanometer, is proportional to the tangents of the angles of deflection*," I verify in the following manner: —

The terrestrial magnetism whose tendency is to direct the galvanometer needle to the magnetic meridian, I make the unit of directive force; and I let this unit be represented geometrically by the line A M, Fig. 1, which is the radius of the circle M B M; the line M A M representing the meridian. When there is no other force acting on the needle, its direction is with the meridian. Now let an electric current be sent through the galvanometer coil, whose directive force is precisely equal to the terrestrial force, and whose tendency is to direct the needle in a line perpendicular to the meridian, and let this force be represented by the line A B.

If the terrestrial force could now, for a moment, be suspended, the needle would point due east and west; but the combined action of the two equal forces will direct the needle toward the point of intersection of the line drawn perpendicularly from M, and that drawn horizontally from B, at 1, which direction cuts the quadrant at 45°, the line M 1 being the tangent of 45°, which is 1.

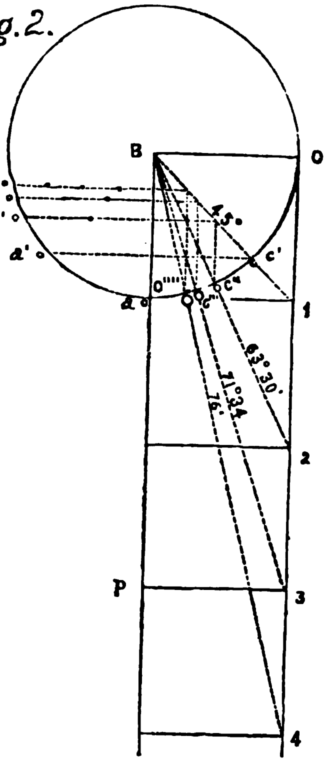
Now, if we augment the intensity of the current through the coil to twice its present force, which will be 2, and will be represented by the line A C, the combined forces A M and A C will direct the needle toward the point 2. If we now lay a protractor on the circle, we find that the line A 2 cuts it at about 63° 30′, of which the tangent is 2.

We may increase the parallelogram, erected upon A M, at pleasure, and the two forces combined will always so balance the needle between them as to make it point from A, diagonally, across the parallelogram to its opposite angle, the height of which is the tangent of the angle of deflection.

By inspection of the diagram it is seen that the law holds good in the subdivisions of the force A B, as at .5, .25, and .125, a truth admitted by all philosophers, as to the relations, up to 14°.

I believe that it is an admitted truth that the correlations of forces in magnetism are the same as those of gravity, — each within its own sphere; that of the former being confined within limits, while that of the latter is coextensive with the universe.

Fig. 2.



Now, let us apply the principles of avoirdupois: here is a wheel which turns freely on its axis, and is graduated to degrees and minutes.

If we attach a pound weight to its periphery at (a) its tendency will be to maintain its position at the plumb-line P a B, which is the line of centres of gravity. Let us suppose the pound weight at (a) to be a constant quantity and a unit of force, corresponding to that of terrestrial magnetism, A M, Fig. 1.

Now, if we attach to the wheel at C a force precisely equal to (a), whose tendency is to assume the position of the force at (a), we shall have two forces acting against each other, and whose relations to each other are the same as those of A M, and A B, in Fig. 1: and they will so adjust the wheel that they will stand equally distant from the line of centres of gravity at a′ and c′, and the wheel will be found to have turned just 45°, the tangent of which is 1. If we now augment the force at c′ to twice its present weight, it will descend to c″, and, at the same time, the weight at a′ will ascend to a″, and the weight at a″ will be found to be just twice as far from the line of centres as that at c″, and the plumb-line will cut the wheel at 63° 30′, the tangent of which is 2. The augmented force is 2, and the tangent of deviation is 2. We may increase the force at c″ as we please, as at c‴ or c⁗, and the wheel will be so adjusted that the distance of the weight at (c), from the line of centres, as compared with that at (a), will be inversely proportional to its weight, and the plumb-line will cut the circle at the degree whose tangent is directly proportional to the weight.

*Therefore: the intensity of currents of electricity, as measured by the true tangent galvanometer, is proportional to the tangents of the angles of deflection of the needle.*

This galvanometer has three distinct coils. No. 1 consists of three layers of No. 32 copper wire, and gives 3.1 miles resistance. No. 2 consists of one layer of No. 28 wire, and gives .4 mile resistance. No. 3 is a simple plate of copper, whose resistance is *nul*, or so small that it need not be taken into account. No. 1 is for intensity, No. 3 for quantity, and No. 2 for common mixed currents.

I now employed a current from 4 cups of Hill's Battery; first through coil No. 1, and then through coil No. 2, against different resistances, from 4.1 to 151.1 miles: the resistance of No. 1 being greater than that of No. 2, I was careful to switch in rheostat coils, so that the sum of the resistances of the galvanometer, and the rheostat coils in the circuit should be always equal, thereby securing *isodynamous*, or equally intense currents.

The resistances introduced in five observations were 4.1 — 11.1 — 41.1 — 81.1 and 151.1 miles. The tangents of the several deflections by No. 1 being divided by those by No. 2, gave the following quotients: 4.4 — 4.3 — 4.4 — 4.44 and 4.3.

The deflections by No. 1 were from 75° to 8° 30′, and by No. 2, from 40° 10′ to 2°. Such results give indisputable evidence of a very true tangent galvanometer. At the same time I noted the deflections of another galvanometer, whose needle is 4 in. long, coil ½ in. wide, and resistance .9 mile, under the influence of the same isodynamous currents. Dividing the tangents of No. 1 by those with this instrument I obtained the following quotients: 2.41 — 1.45 — .84 — .51 and .46. Showing how much more powerfully the needle of the old galvanometer was influenced when near the meridian, and how the effect diminished as compared with that of coil No. 1, when it deflected so as to carry its extremities more and more outside of the narrow coil.

Galvanometers have been constructed of large circular coils, open within, 15 to 20 inches diameter, with a very short needle in the centre, which nearly fulfil the condition required; but the deviations obtained by a given current are small compared with those of an instrument whose needle is close to the coil, and a coil of much greater resistance is necessary. Such galvanometers are large, cumbersome, and inconvenient, and the changes in the deflections are too minute to ensure great accuracy in the observations.

Poggendorff, Melloni, Ampére, and others have published ingenious methods of determining the relative intensities of currents, by any common galvanometer, which may perhaps be sufficiently reliable for ordinary purposes, but in every case laborious computations have to be made and a table or scale arranged with great labor for each individual galvanometer, in order to make it available for any valuable purpose.

The expense and difficulties attending all such methods are such as to render them unavailable for men of ordinary means who cannot afford the requisite time and money.

To measure the resistance of a magnet or coil by the Anthistometer, I put it in connection, between the two front screw cups at the left hand end of the rheostat; the galvanometer being connected between the screw cup at the right-hand end and one pole of the battery while the other pole of the battery is connected with the rear cup at the left end. Now, if we turn the left hand switch to the left, the current goes through the thing to be measured, but if we turn it to the right, it goes through the coils of the rheostat. The resistances of these coils are designated by the figures over the several switches on the front as the equivalent of miles and fractions of a mile. I now turn the current upon the thing to be measured and observe to what degree the needle is deflected, and then turn it upon the rheostat and switch in resistance until the needle settles at the same degree. The sum of the numbers at which the switches now stand gives the resistance.

The switch which turns the current upon the magnet and back on to the rheostat, also the graduated bar and coil which measure hundredths of a mile, are inventions of my own, which give great facility in taking nice and accurate observations.

I have also discovered a new method of determining the resistance of a battery by the *Anthistometer*. To do this I put a cup in connection, as I do a magnet whose resistance I wish to measure. The switches being all at 0, the needle deflects to — say 70° 30′. I now turn the current through the cup, the action of which being added to that of the main battery, the needle deflects to 72° 40′. I now reverse the current through the cup, so that its action opposes that of the main, and the deflection is 65°55′. The tangents of the two extreme deflections are 3.204 and 2.237, which, being added and their sum divided by two, gives 2.720 for the mean tangent, of which the corresponding degree is 69° 50′; by now turning the current through the rheostat and drawing the graduated bar to .20 the needle comes to the same degree (69° 50′). The resistance of the cup is therefore .2 mile. In comparing two magnets for determining their relative working qualities, I remove the galvanometer and put the two magnets in its place, both connected in the same circuit with the rheostat. Let the magnets be adjusted with equal fineness, and then gradually switch in resistance until one or both shall fail to operate. If there is difference in them the better magnet will continue to work after the other shall have ceased.

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## 2. On the Electro-Magnet. By Dr. L. Bradley, of New York.

In presenting my improved Electro-Magnet, I beg to call attention to the first and principal feature of the improvement, namely, the Helix, which was patented August 1st, 1865, and is made of fine naked copper wire, so wound that the convolutions are separated from each other by a space of the six-hundredth to the eight-hundredth of an inch, the spires or layers being separated by thin paper.

In helices of silk-insulated wire, the space occupied by the silk is from the one-hundred-and-fiftieth to the three-hundredth of an inch. A covering that occupies less than the three-hundredth of an inch is not sufficient for safe insulation, without the interposition of paper between the layers. By this mode of winding I make a spool of a given length and size of wire, and of given resistance, to be of much less diameter and to contain a much greater number of convolutions than it is possible to make of silk-covered wire. As the effect of the current in inducing magnetism, in the soft iron core of a magnet, depends upon the number of convolutions and their proximity to the core, the advantages of this compact winding are so manifest that I feel justified in claiming it as an important step in advance toward the perfection of the telegraph.

I feel myself well fortified in this claim by the united testimony of operators generally, where my magnets have been used on long lines in bad weather, and the daily growing demand for them.

The limited resistance which they oppose to the electric current, taken in connection with their superior working powers, is an important consideration in their favor. Unnecessary resistance in a line is very objectionable.

A *desideratum* in telegraphy is a receiving magnet having the greatest effective force, and at the same time opposing the least resistance to the electric current, and this I claim to have attained. I am so sanguine as to the superiority of these magnets that I do not hesitate to invite any manufacturer, or other person, to produce a magnet of silk-insulated wire, and let its resistance be determined; and I pledge myself to furnish one of naked wire, of equal or less resistance, which shall work on a line of same length, and against an equal amount of rheostat resistance, which may even be increased after his shall cease to work.

The low price of these magnets is an important advantage. The cost of silk-covered wire is four to six dollars a pound, while that of naked wire is less than one dollar. Better working magnets, therefore, are offered at $16 each than are sold by other manufacturers at $20.

In making magnets of high resistance I find advantage in using two or more sizes of wire, and such as to keep the diameter of the coil within what I conceive to be the proper limit, say one and an eighth inch, and this I claim as novel. As we increase the diameter of a spool, the resistance increases with accelerated rapidity, namely, as the circumference; or (leaving out fractions) it increases as the diameter multiplied by three, while the magnetizing power increases by a constantly diminishing increment; for my experiments have proved that convolutions at a distance from the core of a magnet do not give equal effect with those that are in close proximity, notwithstanding their greater circumference. Another advantage is gained by the use of helices of small diameter, from the close proximity in which the cores of the magnet may be placed to each other; for it is well known that the poles react, one upon the other, by induction, so as to increase the magnetic force, and the nearer the poles are made to approach each other, the more powerful the magnet becomes from such reciprocal action.

### 3. ON THE GALVANIC BATTERY. By Dr. L. BRADLEY, of New York.

IN addressing myself to the learned members of this Association upon the subject of the galvanic battery, I do not propose to speak of the elementary principles of the battery, or of the *electrodynamic* force generated by it; but to confine myself to the consideration and promulgation of some of the discoveries I have been able to make, aided by the instruments heretofore described in my paper upon the *Anthistometer*, and to the relative merits of such batteries as are now, and as have been employed in telegraphy.

Before proceeding further I will explain what I understand by the words *quantity* and *intensity*, as they are commonly used in this branch of science. These words seem to me to be technical, and to have reference, not so much to magnitude of any kind, as in the common acceptation of the terms, but to peculiar and distinct *properties* of currents.

I define *quantity* as that property of a current which gives it great magnetizing power, as well as great heating and decomposing power. It is the *desideratum* in all electrolytic pursuits, such as throwing down metals from their salts, in galvanizing, electrotyping, etc., but it is not capable of overcoming any great resistance, or of being propagated at any great distance.

It is best obtained by cups having large plates and arranged as simple battery, that is, the positive poles connected, and the negative poles connected, so as to make them equivalent to one large cup.

By intensity I mean that property which overcomes great resistance and renders the current efficacious in being propagated through long lines of telegraphic wire, and in giving severe shocks physiologically. This is obtained by a large number of cups, arranged in compound battery, having the negative pole of one cup connected with the positive of the next, and so on.

There is another property of a current, namely, that which renders it capable of being subdivided, and of intensely charging and operating a number of long lines at the same time.

This is obtained, either by a large number of large cups, or, what is more convenient, a number of parallel series of compound battery, having the similar poles of the several series connected. A current possessing this property, I have presumed to call *volume of intensity.*

I do this with some diffidence for I know that electricians have considered it a simple combination of *quantity* and *intensity*, and have not seemed to notice the distinction I am speaking of; but it seems to me that no portion of this current can exhibit the true properties of a quantity current. There is certainly *one* plain distinction; that is, it does not possess that peculiar negative property of being incapable of overcoming resistance; for the whole or any subdivision of it is truly intense and is capable of overcoming great resistance and of working a telegraph at great distances. It seems to me that the reinforcement of an intensity current by the addition of another of the same quality has the effect of increasing the volume, and not of converting it, in any proper sense, into a quantity current: it therefore seems to merit an appropriate name to distinguish it. I am not tenacious of this name.

The batteries most used in telegraphy are:

Smees' Sulphuric Acid battery,
Grove's Nitric " "
The Chromic " "
And some forms of Sulphate of Copper battery.

Smees' battery has gone nearly out of use, on account of the inconstancy of its current. When a circuit is first closed upon it, it starts off with great energy; but the counteracting effect of the gas which accumulates upon the negative plate causes it gradually to subside. I have seen the galvanometer needle fall back three or four degrees, under the action of a cup of this battery, in the course of twenty minutes. This difficulty and its want of intensity renders it unsatisfactory in telegraphing. But it gives great quantity, and in its electrolytic effects in throwing down metals and other chemical uses it is of great value.

Grove's battery is too well known to require description. The theory of its chemical action is such as to make it more powerful (for a given number of cups) in the combined properties of *quantity*, *intensity*, and *volume of intensity*, than any other battery. But the enormous expense attending its use, together with the deleterious and corrosive fumes of nitrous acid continually emanating from it, are highly objectionable. These difficulties are largely in consequence of local action. If we put a globule of mercury, or a piece of zinc, or of amalgamated zinc, into a tumbler and pour upon it a little diluted nitric acid, a violent effervescence takes place, the tumbler soon becomes too hot to be held by the naked hand, and the air is suffocatingly charged with nitrous acid fumes. This is precisely what takes place in every cup of Grove's battery, just in proportion to the quantity of nitric acid which, by its tendency to diffusion, percolates through the porous cup, and this, I think, may account for the remarkable fact that this battery runs down nearly as fast, when open, or when it works but one line, as when it charges several lines, showing that the consumption of material is due more to this local action than to that which generates the current.

The foregoing objections have caused this battery to go out of use in many places and to give place to the

### *Chromic Acid Battery,*

which consists of the jar, the porous cup, the amalgamated zinc, and the carbon of Bunsen's battery, and which, instead of nitric acid in the porous cup, is charged with a liquid formerly used by Poggendorff, which (De La Rive, vol. II. p. 810) is composed of three parts by weight of bichromate of potassa, four parts of concentrated sulphuric acid, and eighteen parts water. This liquid is so corrosive and oxidizing that it has been found almost impossible to make connections with the carbons that would serve any length of time; but A. S. Ogden, Esq., of Newark, N. J., and C. T. & J. N. Chester, of N. Y., have lately contrived modes of connection which appear to be durable and safe. This liquid has the effect to saturate or fill up the carbons with *sesquioxide of chromium*, which diminishes their conductivity, making it necessary at intervals of 15 or 20 days to renew the battery and submit the carbons to thorough cleansing, by immersion in water for 24 hours or more. The bichromate solution has to be renewed every day for main circuits, and for local circuits twice a day. This battery is properly called *chromic acid battery*, in contradistinction to the nitric acid batteries of Grove and Bunsen. Chromic acid is the active ingredient in the porous cup. The greater attraction of the sulphuric acid takes the potassa, and the chromic acid is set free. But the quantity is so limited (not more than one twenty-fifth of its weight) that the battery can never be but short-lived and inconstant.

The facility with which chromic acid parts with oxygen to form water with the hydrogen, which would otherwise appear in a free state at the negative plate, is such as to make this battery superior for its quantity, as well as its intensity property. When we form connection, by contact of a short ground wire, a brilliant flame of fire is elicited, which has been referred to by respectable electricians as a property highly meritorious.

It is meritorious in a battery for electrolytic purposes, but in telegraphy it is the reverse; it indicates a kind of force that is not only liable under certain circumstances to heat and destroy the magnet, but is prone to escape at every possible opportunity. Every particle of aqueous vapor that touches the telegraph wire receives and carries off a full charge, and every cobweb or other fibrous material, that may chance to hang across the wire in a damp atmosphere, carries off a stream of fire.

On the whole, it seems like a hard choice of evils to take this, in place of Grove's battery; indeed the objections to both are serious and call loudly for something better. In my numerous testings with both the chromic acid and the nitric acid batteries, I have always been annoyed with irregularities in their action. I have sat for hours to observe the perturbations of the galvanometer needle under their action. When using the quantity galvanometer I have observed the needle to vibrate, sometimes gently and steadily and at others abruptly, to the distance of four or five degrees, and have seen it moving back and forth over an arc of 10° or 12° in the course of an hour. These vibrations are not so large where I use the intensity galvanometer.

There is another battery, a peculiar modification of the *sulphate of copper battery*, which, on account of its extraordinary merits, is now coming rapidly into use and promises to take the place of all others in telegraphing. It is the invention of Dr. E. A. Hill, of Chicago, Ill., who obtained a patent for it August 18th, 1834. In the midst of a long experience in the use of the common sulphate of copper battery (Daniel's Battery) he observed that when there was nothing to prevent, the sulphate of copper was first withdrawn from the upper part of the solution, and that frequent agitation was required to restore the diffusion.

The practical idea, therefore, suggested itself to his mind, of discarding the porous cup, placing the copper in the bottom of the vessel where experience had taught that the sulphate of copper solution maintained itself the longest, and suspending the zinc in the upper part where it would be out of the way of the copper solution, and least exposed to local action. The idea being carried out in practice, he claims, and I think justly, that the most simple and philosophic battery ever produced was obtained. The use of the battery for more than three years has demonstrated that for economy, constancy, durability, and ease of management, it is superior to all others.

A battery of 150 cups charged 8 and 9 lines well, at the Chicago office of the Illinois and Missouri Telegraph Company, at greatly reduced cost compared with the Grove battery previously used. A battery of 100 cups, at the United States telegraph office, New York, charged 2 Boston lines most satisfactorily for 50 days with the loss of 53 lbs. Sul. Cu., the equivalent of zinc being 14 lbs. The cost of these in New York was just $10.

The whole fire-alarm telegraph of this city (Buffalo) is run by 96 cups of this battery.

I learn from a statement of Mr. Wm. A. Sheldon, chief operator, that 30 cups work the local, 62 cups work two signal circuits, each 5 miles long, and 4 cups the test battery; all but the last four are kept closed night and day. Since June 28th to 17th inst., 50 days, the expenditure of Sul. Cu. has been 168 lbs., the zinc equivalent being 42 lbs., and cost $31.50. The 30 lbs. pure copper deposited has been saved, which is certainly worth $12 or $15.

I have experimented much in ascertaining the interior resistance of the various batteries. I do this by the method described in my paper on the *Anthistometer*, also by equations involving two unknown quantities.

### BY OHM'S LAW,

$$\frac{e}{r} = S \text{ and } \frac{e}{r + r'} = S', \text{ in which}$$

e = Electromotive force,
r = Interior resistance,
r′ = Exterior, inserted resistance,
S = Strength of current in circulation,
S′ = Strength where r′ is inserted.

By eliminating (e) and reducing the equation we have,

$$r = \frac{r' S'}{S - S'}.$$

In using my true tangent galvanometer for quantity (whose resistance is so small that it need not be taken into account), I note the deflection which the battery gives; I then insert some known resistance (r′), say a wire or coil of 0.2 mile, and note the reduced deflection. The tangents of these two deflections give S and S′. We have then the known quantities r′, S and S′, from which by the formula we compute (r), the interior resistance.

The results obtained by the two methods agree almost perfectly.

The interior resistances of the nitric acid and the chromic acid batteries, under different circumstances, I have found as follows, — the circuit being always kept closed on a common local sounder, which gave 0.3 mile exterior resistance.

| | Mile. |
|---|---|
| 1 cup Grove's battery (new), r = . . . . . . . . . | 0.047 |
| Same after running 8 hours, " . . . . . . . | 0.068 |
| " " " 16 " " . . . . . . . . . | 0.140 |

| | |
|---|---|
| 1 cup chromic acid battery (new), r = . . . . . . | 0.027 |
| Same at 6 hours, " . . . . . . . . | 0.062 |
| " 16 " (about run down), " . . . . . . . . | 0.154 |

With Hill's battery, properly attended, (r) ranges from 0.15 to 0.25 mile (according to the size of the cups), at all times. The resistance of the same cup scarcely varies 0.02 mile, from month to month. The unit of resistance is that of one mile No. 8 iron wire. The value of (r) is a very good index to the relative constancy and durability of the several batteries.

As to the cost of material actually consumed in running these several batteries, I have some data, which are deemed reliable, from which I select cases when the batteries performed about equal service in running two long lines each, which give the following results, namely: —

| | |
|---|---|
| Grove's battery, per cup per month, . . . . . | \$.109 |
| Chromic acid battery " . . . . . . | 31¼ to 35 cts. |
| Hill's battery " " . . . . . . | 5¼ to 6 do. |

Now we may concede that ten cups of this last battery are required to perform what might be done by four cups of either of the former.

We see that economy, financially, is greatly in its favor; for the monthly expense is not half that of the chromic acid, nor one-seventh that of Grove's. If many lines are run from the same battery, the economy in the use of Grove's gains considerably upon the others, but never comes up to that of Hill's battery.

But this financial economy is nothing compared with the advantage and satisfaction derived from so smooth and constant a current as is given by Hill's battery.

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## 4. ON PETROLEUM. By Dr. T. STERRY HUNT, of Montreal, Can.

[Abstract.]

THE author adverted to the history of certain views relative to Petroleum. He had shown, in 1861, that the mineral oil of western Canada was indigenous in the coniferous limestone; wells, sunk in the outcrop of which have yielded, and still yield, oil in that region, and, also, in Kentucky, according to Lesley. At that time, 1861, he called attention to the existence of petroleum in the limestone of the Trenton group, and had, since then, in the "Geology of Canada," in 1863, insisted upon these lower silurian oils as likely to prove in some regions of economic importance, — a prediction verified by the recent developments in the lower silurian strata of the Cumberland, in Kentucky, and the oil-wells of the Manitoulin Islands, which latter are sunk through the Utica into the Trenton formation. Another important point, on which he had been the first to insist, was that the accumulations, giving rise to productive wells, occur along the lines of anticlinal folds, where the oil would naturally accumulate in fissures or in porous strata, in obedience to well-known hydrostatic laws. This view, first insisted upon in a lecture published in the Montreal Gazette for March, 1861, was further developed in a paper on petroleum in the Canadian Naturalist, for July, 1861, and simultaneously by Prof. E. B. Andrews, in Silliman's Journal. Since then this view, though greatly opposed, is gaining ground; and, according to Prof. Andrews and Dr. Newberry, is sustained by all experience in the oil fields of the United States, as it also is in Canada. This remark applies to large accumulations and to flowing wells; but oils may doubtless flow slowly from horizontal strata containing it.

As to the origin of the petroleum, Dr. Hunt supposes that it is indigenous in the two limestone formations already mentioned, and that it may have from these risen and accumulated in overlying pervious strata or in fissures capped or sealed by impervious beds, such as Pennsylvania sand-rocks or quarternary gravel-beds.

He is inclined to think, however, that petroleum may also be indigenous in certain sandstones of Devonian or Carboniferous age, and referred to Lesley's observations to this effect, closely agreeing with those of Wall and Crüger, in Trinidad, where fossil plants are sometimes found partly converted into petroleum and partly into lignite. Dr. Hunt regards the process by which animal and vegetable hydrocarbonaceous tissues have been converted into solid or liquid bitumens, as a decay or fermentation, under conditions in which atmospheric oxygenation is secluded, so that the maximum amount of hydrogen is retained by the carbon, and as representing one extreme of a process, the other of which is found in anthracite and mineral charcoal; the two conditions being antagonistic and secluding each other, and the production of petroleum implying, when complete, the disappearance of the organic tissue. Hence, pyroschists — the so-called bituminous shaler and coal — are not found together with petroleum, but in separate formations; and it is to be borne in mind that the epithet, bituminous, applied to the former bodies, is a mistaken one, since they seldom or never contain any bitumen; although, like all fixed organic bodies, they yield hydrocarbons by destructive distillation. The fallacy of the notion which ascribes petroleum to the action of subterranean heat on strata holding coal and pyroschists was exposed; and it was remarked, among other arguments, founded upon the impermeability of many of the petroleum-bearing strata, that the oil of the Trenton limestone occurs below the horizon of any pyroschists or other hydro-carbonaceous rocks.

## 5. ON THE METALLURGICAL SYSTEM OF MESSRS. WHELPLEY AND STORER. By Dr. T. STERRY HUNT, of Montreal, Canada.

THE metallurgical processes recently introduced by Messrs. Whelpley and Storer, of Boston, are the perfected results of a long study of the chemical and mechanical conditions required for the economic working of metallic ores. Most of the valuable metals generally exist in nature combined with sulphur. This is the case with a large amount of iron, and the greater part of the copper, lead, zinc, and silver; gold, too, is often involved in these sulphurets. The extraction of the metals from their sulphurets is, therefore, one of the most important problems of metallurgy. The common method, as illustrated in the case of the ordinary ores of copper, consists in roastings and fusions, having for their object: 1st. The separation of the earthy matters and the excess of sulphur which keeps in combination with the copper a portion of iron; 2d. The final elimination of the sulphur and the conversion of the copper into an oxide; and, 3d. The reduction of the oxide to the metallic state. This series of operations is long and costly from the large amount of fuel consumed, so that the working of copper is generally confined to coal-producing districts, or to localities where the copper ores can be cheaply brought in contact with coal, fifteen tons of which are consumed in Swansea to produce one ton of copper.

The chemist in his laboratory separates copper from its sulphuretted ores in a very simple and direct manner, by first converting it into a soluble salt, from which the pure metal is precipitated by an equivalent of iron. To apply this principle to the working of copper ores on a great scale is a problem which has engaged the attention of many metallurgists, and has given rise to various processes for obtaining copper by the moist way, many of which are nearly or quite perfect in their operation, but are lacking in practicability and cheapness. The sulphurets of copper, zinc, and some other metals, when calcined, give rise to oxides which readily unite within certain limits of temperature with the oxidized sulphur and give soluble compounds, while the sulphuret of iron under similar conditions yields a peroxide which is comparatively indifferent to acids. The first condition of this oxidation is minute subdivision, which being attained the calcination is generally effected in a reverberatory furnace, with frequent stirring to bring each particle of ore in contact with atmospheric oxygen; and here come into play the mechanical peculiarities of the new method. Rejecting the stamps generally employed, Messrs. Whelpley and Storer have invented a new system of mills for crushing and pulverizing. By falling upon a large circular iron table, revolving about 2,000 times in a minute, having hammers bolted to its surface, and surrounded by a perforated screen, masses of ore are at once shattered to fragments, which are thrown out through the openings in the screen. In the next stage the material thus broken up is pulverized in an air-mill, where in a fixed cylinder, is a shaft armed with iron paddles, whose extremities approach within an inch or two of the periphery of the cylinder, and are made to revolve about 10,000 feet in a minute. The grains of ore falling in near the axis of this rapidly rotating system are, carried at once to the periphery by their mutual attrition, speedily reduced to an impalpable powder. The only escape for this is by the open axis of the cylinder, through which, by means of a fan-blower or aspirator contiguous to the mill, or somewhat removed, a current of air is drawn, by which the fine dust is removed and carried to receiving chambers. This novel method yields surprising results: a mill forty-two inches in diameter, moved with fourteen horse-power, will reduce to impalpable powder from one to two tons per hour of crushed material, such as ores, quartz, coal, etc., brittle substances being more easily pulverized than soft and tough ones, like bones, for which these mills are now largely employed. They are also adapted to the grinding of drugs, grain, and other vegetable substances. Besides its cheapness, this novel method of grinding secures a far greater subdivision than can be attained by stamps, which fits the particles of ores for an instantaneous roasting or calcination in the second part of the process. This is effected in a tall cylindrical furnace, fed from the top with air, and with pulverized fuel and ore, and having at the bottom a water-tank to receive the solid products of combustion, after which the gases pass through a series of chambers, being drawn by a fan-wheel in a farther chamber, which throws the water into spray, and thereby greatly facilitates the absorption and the production of sulphuric acid. A second spray-wheel farther on, fed with milk of lime, absorbs the remaining sulphurous acid from the furnace, and thus prevents the escape of noxious vapors from the furnace. This arrangement also permits, if desired, the complete utilization of the burned sulphur, by converting it into oil of vitriol, by well-known processes. The furnace is fed by a copious supply of air from large fan-blowers, and around its head are small fire-boxes opening into the furnace, the flame from these being drawn downward by the blast. Here comes into use an important method of applying fuel: coal, pulverized by the mills just described, is floated in the descending current of air, and, being kindled by the flame from the fire-boxes, burns with great energy, producing a solid mass of fire, which may be compared to the oxidizing flame of the blow-pipe, but is made either oxidizing or reducing by varying the supply of fuel, and with an excess is so intensely luminous that it may perhaps be used as a source of artificial light. This mode of using fuel is also applied by Messrs. Whelpley and Storer to the heating of reverberatory furnaces, and to the generation of steam, and seems full of promise for the future of the arts, offering a great economy of fuel; inasmuch as it is direct and simple, and moreover allows of the ready utilization of waste and comminuted coal, which is well adapted for this use. When once heated, however, this furnace requires but little fuel; for the sulphuretted ores, borne downwards by the blast of air, burn with almost explosive violence in the hot atmosphere, evolving much heat by their own combustion, and becoming completely oxidized at the rate of two or three tons an hour. The calcined dust falls in the water beneath, where the movement of a screw propels it constantly forward. The water soon becomes charged with acid from the fumes condensed in the chambers which are built over the tank, and a large amount of copper is taken into solution, to be subsequently separated as copper of cementation. The insoluble residue, besides iron-oxide and earthy matters, contains a portion of oxide of copper, which must be rendered soluble by a second calcination, for a short time, at a low red heat, in a reverberatory or muffle furnace, with certain additions which render the whole of the copper soluble either in water or in dilute acids, and thus permit a complete separation of the metal from its ores with a cheapness and a celerity hitherto unattained. These advantages are chiefly due to the new methods of pulverizing and oxidation embodied in the mills and the furnace. The details of the processes employed by the inventor for the preparation of spongy metallic iron to be used in precipitating the copper, and the treatment of the resulting sulphate of iron, are matters which, like that of the economy of the sulphur, would lead us too far. The application of this furnace to zinc ores, the complete conversion of blende into soluble sulphate of zinc, its separation in this way from lead, and the subsequent treatment of the zinc salts, can here only be alluded to. In reference to gold ores, however, the bearings of the new system are most important. For gold-bearing quartz the minute division of the mineral effected by the pulverizers renders the process of amalgamation much more efficient. The particles of gold, instead of being flattened and extenuated as under the stamps, so as to be readily floated away on the water by simple washing, are rounded into pellets by the same action which reduces to dust the more brittle gangue. This same effect might probably render the mills valuable for working the mixture of native copper and rock found in the Lake Superior mines, by reducing the rock to powder, while the copper grains would accumulate in the cylinder, and could be removed from time to time.

But it is especially for those ores in which gold occurs with larger amounts of pyrites, or other sulphurets, and wherever preliminary calcination is required to completely decompose and oxidize these, and possibly liberate a portion of chemically combined gold, that the new system will be found advantageous. Such are many of the Colorado ores, which contain large amounts of gold, but yield only a very small proportion of it by the ordinary process of amalgamation. By the minute subdivision of such ores, their rapid and complete oxidation, and the solution and removal of the copper and zinc which they often contain, the gold will all be left free and ready for amalgamation, or for extraction with chlorine. This process seems theoretically perfect, and will, I believe, open a new era for the mining industry of Colorado and similar mineral regions. This series of inventions relating to the crushing and pulverizing of materials, the application of fuel, and the treatment of metallic ores, which the world owes to the genius and untiring energy of Messrs. Whelpley and Storer, is capable of such wide and varied application, that it is probably destined to have a very important influence on the industry of the world.

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## 6. ON THE PRIMEVAL ATMOSPHERE. By Dr. T. STERRY HUNT, of Montreal, Canada.

DR. HUNT adverted, in commencing, to a theory, first put forward by him, to explain the chemical conditions of our globe. Starting from the notion of an igneous origin, he had contended, that the mass probably commenced cooling at the centre, and thus gave rise to an anhydrous solid nucleus, having a crust of silicates with an irregular surface, while the chlorine, carbon, and sulphur, together with all the hydrogen and an excess of oxygen, formed the atmosphere. As cooling from radiation went on, the first precipitate from this dense atmosphere must have been an intensely acid liquid, which, attacking the crust of silicates, separated vast amounts of silica and became saturated with earth and alkalies, forming the primeval sea. This condition of things he claimed was in strict accordance with known chemical laws, and flowed logically from the hypothesis of the igneous origin of our planet. The early ocean should thus abound in salts of lime and magnesia, and this is confirmed by the saline waters from the paleozoic rocks which represent fossil sea-water of that ancient period. Dr. Hunt here referred to his extended chemical and physical investigations of the older rocks, in relation to their mineral springs, in support of this view.

The stronger acids of chlorine and sulphur having been separated from the atmosphere, a decomposition of the silicates of the exposed portion of the earth's crust, under the influence of carbonic acid, moisture, and heat, went on, resulting, like the modern process of kaolinization, in the production of a silicate of alumina or clay, and carbonates of the protoxide base. In this way great quantities of carbonate of soda were formed, which, decomposing the lime and magnesia salts of the sea, gave rise to the first limestones, and to chloride of sodium. Hence the clays, the limestones, and the sea salt were the joint results of a process which was slowly removing from the air its carbonic acid, and fitting it for the support of higher forms of life. These views of Dr. Hunt, first put forward in 1858 and 1859, are gradually being received and appropriated by writers who do not always acknowledge the source of them. They are here insisted upon as preliminary to some considerations on the atmosphere of early times, when it must have contained, in the form of carbonic acid, the whole or the greater part of the carbon now present in the limestone strata of the earth, and in its beds of fossil coal.

Simple calculations show that the carbonic acid contained in a layer of pure carbonate of lime extending over the earth with a thickness of 8.61 metres would, if set free, double the weight of our atmosphere, and that from 13.26 metres (about forty-four feet) would double its volume. It, moreover, appears, that a similar layer of ordinary coal, one metre in thickness, would suffice to convert into carbonic acid the whole of the oxygen of the atmosphere. So that if, as is probable, the whole amount of coal and carbonaceous matters in the earth exceeds this quantity, there must have been an absorption of the oxygen set free during the conversion of carbonic acid into coal; this oxygen being probably retained by peroxide of iron. Disregarding this, however, and admitting that the carbonic acid, corresponding to a layer of 8.61 metres of limestone (about 28 feet), were present in our atmosphere, the effects would be most remarkable. The heighth of the barometric column would be doubled; the boiling-point of water raised to 121° centigrade (250° F.), and as the absorptive power of an atmosphere of carbonic acid is, according to Tyndal, ninety times that of dry air, the temperature of the lower regions of the atmosphere would be greatly elevated, and the whole climatic conditions of the earth modified. Yet, as the amount of carbonic acid required to produce these results is probably but a small proportion of that now fixed in the limestones of the earth's crust, we should find this condition of things at a period geologically not very remote; and, in still earlier times, the earth must have had a far denser and more highly carbonated atmosphere than that just supposed. The relations of such a condition of things to the animal and vegetable world furnish fruitful themes for conjecture and experiment; and its influence on chemical processes is not less worthy of consideration, as a single instance will show. Some years since I pointed out that the explanation of the almost constant association of gypsum and magnesian limestones in nature was to be found in the fact that solutions of bi-carbonate of lime and sulphate of magnesia decompose each other, with production of solutions of sulphate of lime and bi-carbonate of magnesia. By spontaneous evaporation, the former may be in part separated as gypsum; but, as in this process the bi-carbonate is changed into mono-carbonate of magnesia, this partially decomposes the gypsum, regenerating carbonate of lime, and the results of the experiment, in an ordinary atmosphere, are imperfect. I find, however, that by infusing into the drying atmosphere a large proportion of carbonic acid, the separation by evaporation goes on regularly, and the gypsum is deposited in a pure state, enabling us thus to realize the conditions of earlier geologic periods, when vast beds of gypsum, with their accompanying magnesian limestones, were deposited in evaporating basins at the earth's surface, beneath an atmosphere charged with carbonic acid.

Ebelman has speculated on the probable existence of a much larger proportion of carbonic acid in the atmosphere of earlier geologic times, and Dana, Tyndal, and anterior to them the late Major E. B. Hunt, have considered its meteorological relations; but the chemical history of this carbonic acid, considered with reference to its origin, its fixation in the form of limestones, and its influence on chemical processes at the earth's surface, are points for the most part peculiar to the author, and, in part, now brought forward for the first time.

### 7. ON CRYOPHYLLITE, A NEW MINERAL SPECIES OF THE MICA FAMILY, WITH SOME ASSOCIATED MINERALS IN THE GRANITE OF ROCKPORT, MASSACHUSETTS.[1] By Prof. JOSIAH P. COOKE, JR., of Cambridge, Mass.

THE species of the Mica family, previously described, have the general formula $2RO,SiO_2$, and have an oxygen ratio of 1 to 1. At least, this may be regarded as the normal ratio, for the micas are very variable in their composition, and the analyses have given results varying all the way between the above ratio, which is usually regarded as the normal type, and the ratio of 1 to 1½, which has been the extreme limit of variation hitherto observed. The new mica has the general formula $RO,SiO_2$, with the oxygen ratio of 1 to 2, and on this is based its distinction as a new species. Moreover, it is associated with a second mica, belonging to the species lepidomelane, of the normal type, and the common mica of the granite rock of the region. Further, the lepidomelane of Rockport, although perfectly identified by its mineralogical characters, varies in its composition from the well-known normal type, and this variation may be traced to an admixture of cryophyllite. Lastly, cryophyllite and lepidomelane are isomorphous, and the admixture of the two is an example of isomorphous mixtures, studied by Rammelsberg and others, in the case of artificial salts.

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[1] This paper has been published in full in the American Journal of Science and Arts, Vol. XLIII., March, 1867. Only an abstract is given here.

*Oryophyllite* crystallizes in six-sided prisms with a highly perfect basal clearage, and yielding thin, flexible, and transparent laminæ, which, when examined with a polarizing microscope, give a biaxal image, the angle between the optical axis varying from 55° to 60°. The crystals are trimetric, as shown both by the symmetry of the biaxal image and the mode of twinning. The color of the laminæ is dull emerald-green, like bottle glass, but the crystals are dichrous, and appear brownish-red in the direction of the lateral axis. Streak light-gray, with only a tint of green. Lustre brilliant, inclining to resinous or clearage face. Hardness 2 to 2.5. Sp. Gr. 2.909. Before the blow-pipe very easily fuses, with some intumescence, to a grayish enamel bead, imparting to the flame a brilliant lithia reaction, and even fuses in flakes of considerable size in the flame of a candle; hence the name after the analogy of cryolite.

Of the analyses given in the following table, 1 and 2 were made in the usual way, but 3, 4, and 5, were made by a method described in the original paper above referred to, which gave primarily the amount of fluoride of silicon, but also incidentally the amount of silica and the sum of the weights of all the bases present, which furnishes an important test of the accuracy of the first two analyses.

*Analysis of Cryophyllite from Rockport.*

| | 1. | 2. | 8. | 4. | 5. | Mean. | Oxygen. | |
|---|---|---|---|---|---|---|---|---|
| Silica, | 51.53 | 51.54 | 51.65 | 51.37 | 51.36 | 51.49 | 27.46 | |
| Fluoride of silicon, | | | 3.29 | 3.34 | 3.62 | 3.42 | 1.06 | =28.52 |
| Alumina, | 16.76 | 16.77 | 45.06 | 45.29 | 45.02 | 16.77 | 7.82 | |
| Sesquioxide of mang. | 0.33 | 0.35 | | | | 0.34 | 0.10 | |
| Sesquioxide of iron, | 2.00 | 1.94 | | | | 1.97 | 0.59 | = 8.51 |
| Protoxide of iron, | 8.00 | 7.96 | | | | 7.98 | 1.76 | |
| Magnesia, | 0.76 | | | | | 0.76 | 0.30 | |
| Potassa, | 13.14 | 13.16 | | | | 13.15 | 2.23 | |
| Lithia, | 4.05 | 4.06 | | | | 4.06 | 2.16 | = 6.45 |
| Soda, | *trace.* | | | | | *trace.* | | |
| Rubidia, | " | | | | | " | | 14.96 |
| | | | | | | 99.94 | | |

Oxygen ratio, 14.96 : 28.52
14.26 : 28.52=1 : 2.

*Lepidomelane* has the same crystalline form as cryophyllite, which it resembles so closely in crystalline characters and outward appearance, that it is not easy to distinguish the two by the eye alone. The cleavage is basal and perfect, but not so eminent as in most micas, and the foliæ are not at all or only slightly elastic. Color black, and streak dark-green. Laminæ opaque, unless very thin. Lustre very brilliant, inclining to resinous on cleavage face. Hardness 3. Sp. Gr. 3.169. Before blow-pipe it fuses to a black enamel bead, which is highly magnetic, the fusibility being about that of iron garnet. Heated in closed tube gives off water, and its green color changes to pinchbeck brown.

### *Analysis of Rockport Lepidomelane.*

| | 1. | 2. | 3. | 4. | 5. | 6. | 7. | 8. | Mean. | Oxygen. |
|---|---|---|---|---|---|---|---|---|---|---|
| Silicia, | 39.50 | 39.49 | —— | 39.79 | 39.43 | —— | —— | —— | 39.55 | 21.09 |
| Fluoride of silicon, | | 0.62 | —— | —— | —— | —— | —— | —— | 0.62 | 0.19=21·28 |
| Alumina, | | 16.72 | 16.41 | 16.90 | 16.87 | —— | —— | —— | 16.73 | 7.81 |
| Sesquiox. of mang. | | —— | 0.63 | 0.58 | 0.59 | —— | —— | —— | 0.60 | 0.18 |
| Sesquiox. of iron, | | —— | —— | —— | —— | 12.21 | 12.01 | 11.98 | 12.07 | 3.62 |
| Protox. of iron, | | —— | —— | —— | —— | 17.57 | 17.47 | 17.41 | 17.48 | 3.88 |
| Magnesia, | | —— | —— | 0.64 | 0.59 | —— | —— | —— | 0.62 | 0.25 |
| Potassa, | | —— | —— | 10.68 | 10.63 | —— | —— | —— | 10.66 | 1.81 |
| Lithia, | | —— | —— | 0.60 | 0.57 | —— | —— | —— | 0.59 | 0.32 |
| Soda, | | —— | —— | —— | —— | —— | —— | —— | *trace.* | —— |
| Rubidia, | | —— | —— | —— | —— | —— | —— | —— | " | —— |
| Water, | | —— | —— | 1.55 | 1.40 | 1.52 | 1.52 | 1.54 | 1.50 | 1.33=19.20 |
| | | | | | | | | | 100.42 | |

Oxygen ratio, 19.20 : 21.28.

After an examination of the results of the above analysis, no one can doubt that the true oxygen ratio of the mineral is 1 : 1, and that the general formula is $2RO,SiO_2$ or $2(\frac{1}{2}\dot{R}^3 . \frac{1}{2}\,\text{-}\ddot{R}\text{-})3\ddot{Si}$. This is not only the nearest probable formula, but moreover it harmonizes with the well established formulæ of allied species and with the results of Soltmann's analysis of lepidomelane, a mineral which our Rockport mica resembles most closely in all its characters. Nevertheless the discrepancy between the actual and the probable ratio is very great, and cannot possibly be referred to impure material or imperfect processes. Here, then, are the same unsatisfactory results, which have been obtained again and again in the analyses of the micas, and have made it so difficult to reduce to order this important family of minerals. Fortunately we find at the Rockport locality what I believe to be the clew to the whole mystery. The common mica of the granite is there associated with a second mica containing twice as much silica, but still perfectly isomorphous with it in crystalline form. Now, if two isomorphous salts crystallize together from the same solution, we obtain crystals which are mixtures of the two in definite proportions, the proportions depending chiefly on the relative quantity of each which may be present; but also at times on other conditions less accurately determined.[1] When the sedimentary rocks were undergoing the metamorphism which converted them into the granite ledges of Rockport, or when by any other means this granite was formed, the two isomorphous micas, described in this paper, did actually crystallize together, for so we find them; and it is reasonable to suppose that the same results followed in the one case as in the other, and that the mica of the Rockport granite is an isomorphous mixture of these two distinct species. This conclusion, moreover, is favored by the fact that lepidomelane — the species to which this mica undoubtedly belongs — contains in other localities neither lithia nor fluorine; while, on the other hand, these same ingredients are strikingly characteristic of the lepidolite micas, to which cryophyllite is allied. Assuming, then, that the lithia and fluorine in the analyses belong to the cryophyllite and not to the lepidomelane, we have endeavored in the following table to eliminate this disturbing element from our results. Thus, in column 1 we have repeated the mean result of our analyses. In column 2 we have the amounts of the several ingredients of cryophyllite corresponding to 0.59 per cent. of lithia, deduced from the analyses of this mineral given above. Substracting these quantities from those in the first column we have the numbers in the third column. In column 4 we have reduced the same to a percentage composition, and these numbers, according to our theory, represent the true composition of the Rockport lepidomelane. In column 5 we have placed for comparison the analysis of lepidomelane by Soltmann.

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[1] See Rammelsberg's important paper on this subject, Pogg. Ann., xci. 321.

*Reduction of Analyses of Lepidomelane.*

| | 1. | 2. | 3. | 4. | Oxygen. | 5. | Oxygen. |
|---|---|---|---|---|---|---|---|
| Silica, | 39.55 | 7.48 | 32.07 | **37.39** | ....=19.94 | **37.40** | =19.94 |
| Fluoride of silica, | 0.62 | 0.50 | .... | .... | .... | | |
| Alumina, | 16.73 | 2.44 | 14.29 | **16.66** | 7.78 | **11.60** | 5.42 |
| Sesquiox. of manganese, | 0.60 | 0.05 | 0.55 | **0.64** | 0.19 | | |
| Sesquiox. of iron, | 12.07 | 0.29 | 11.78 | **13.74** | 4.12 | **27.66** | 8.29 |
| Protoxide of iron, | 17.48 | 1.16 | 16.32 | **19.03** | 4.23 | **12.43** | 2.76 |
| Magnesia, | 0.62 | 0.11 | 0.51 | **0.59** | 0.24 | **0.26** | 0.10 |
| Potassa, | 10.66 | 1.91 | 8.75 | **10.20** | 1.73 | **9.20** | 1.61 |
| Lithia, | 0.59 | 0.59 | .... | .... | .... | | |
| Water, | 1.50 | .... | 1.50 | **1.75** | 1.56=19.85 | **0.60** | 0.53=18.71 |
| | | | | **100.00** | | **99.15** | |

Oxygen ratio, 19.85 : 19.94 = 1 : 1.

General formula, $2RO, SiO_2$. Probable rational formula, $2\,(\frac{1}{2}\,\dot{R}^3,\ \frac{1}{2}\,\ddot{\bar{R}})\,\ddot{Si}$.

The result of our calculation, as will be seen, is most satisfactory; for not only is the oxygen ratio thus obtained exact, but also the numbers agree very closely with those of Soltmann, the only apparent discrepancies disappearing when the sum of the alumina and the oxides of iron and manganese are compared together in the two analyses, and the difference in the distribution of the iron between the two oxides being unimportant if we assume with many mineralogists that these oxides may replace each other.

The facts advanced in this paper seem to show quite conclusively that the variation in composition of the Rockport lepidomelane from the normal type is caused by the admixture of a second isomorphous mica with a higher oxygen ratio, which we have called cryophyllite, and this being the case we may expect to find that similar variations in the composition of other micas are due to a similar cause, and it will therefore be interesting to search for the disturbing element at the various localities. Such an examination will be likely to reveal either the presence of cryophyllite itself or else of some new species analogous to it; and, if the Rockport locality is any guide, such minerals are more likely to be found in feldspathic veins or nodules of the granite, rather than uniformly diffused through the rock itself. It is a fact worthy of notice, and which is quite evident from the above analyses, that the proportions in which cryophyllite is mixed with lepidomelane are quite constant in all the specimens analyzed; and this again is wholly in accordance with the well known facts which have been developed by Rammelsberg and others in regard to the crystallization of isomorphous salts when mixed together in the same solution. It appears from these investigations that isomorphous salts do not necessarily crystallize together in every proportion, but that, in most cases at least, any two given salts have, so to speak, a definite capacity for each other, and that when the point of saturation is passed, pure crystals of the salt in excess may be deposited in direct contact with those which are mixtures of the two. Such experiments furnish an exact counterpart of the conditions which we actually realize in the Rockport granite.

With the two micas described in this paper there are also associated at Rockport, Orthoclase, which is frequently colored green, Albite, and a peculiar variety of altered Zircon, distinguished by the strong curvature of the pyramidal faces. Of the last a complete analysis has not yet been made, but it closely resembles in its mineralogical characters the Malacone of Scheerer.

# PART II.

## B. NATURAL HISTORY.

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## I. GEOLOGY.

### 1. On the Ice Movements of the Glacial Era in the Valley of the St. Lawrence. By Col. Charles Whittlesey, of Cleveland, Ohio.

In an article which will appear in the "Smithsonian Contributions" to Science, I have treated of the drift-period in a descriptive way. The rules of publication adopted by the Smithsonian Institution preclude theoretical discussions upon the subjects which appear in their volumes, and I take this opportunity to complete the expression of my views upon the ice-period.

For the principal facts I refer to the forthcoming number of the "Contributions." It is necessary, however, to repeat some of them. From the easterly part of Lake Ontario, along the waters of the upper lakes, as far as the Lake of the Woods, the drift materials are of *fresh-water origin.*

The evidence on this point is all in one direction, without anything to lead to doubts. All the shells hitherto described are of fresh-water growth, or are land shells, or amphibious. The formation consists of *three members,* not always very distinct, but traceable on close examination. In many instances only one member exists; but where there are two, or more, they always occur in the same order. Beginning at the surface of the indurated rocks, as a base, and reckoning upwards, they are found as follows: —

1st. Blue mottled and red laminated marly clay, thickness sometimes only a few feet, increasing to 500 and 600 feet, filling the lake basins, and rising several hundred feet above their surfaces.

2d. Coarse water-washed sand and gravel, in beds of small extent locally, passing into compact "hardpan," not stratified.

3d. Coarse boulder drift, frequently in layers of limited extent, and occupying the highest summits in the country. In all these members there are pebbles, which are transported, but mingled with those belonging to the underlying rocks.

As we rise in the series, the size of the pebbles increases, and also their number, and the proportion of fine materials decreases. Large boulders are rare in members No. 1 and 2, but when found they belong to the same rocks as those in No. 3. The upper member (No. 3) is constituted principally of coarse gravel, stones, and boulders. There is generally earth mingled with the coarse materials, but on the highlands adjacent to Lake Superior there are frequently seen tracts of boulders, without soil or gravel, embracing several square miles, and of great thickness. The middle member (No. 2) is due to a transition state from the laminated clay to the boulder masses. Here the beds of clay and sand alternate in limited bands, which taper out in all directions. In all the members there are found the leaves, branches, and trunks of trees, most of which are northern evergreens.

They are not mineralized, and in general not entirely rotten, sometimes quite hard and sound. Where there are patches of leaves and sticks in the clayey portion, they are sometimes carbonized and brought to a state resembling lignite, communicating a dark color to the mass. The branches and trunks of trees are occasionally saturated with sulphate of iron, filling the pores and interstices. Teeth and grinders of the elephant, mastodon, and horse are found in the two upper members, and in the alluvion, which rests upon them; showing that these animals existed here prior to the drift era, and survived after it had passed.

Boulders are everywhere more numerous upon the surface than they are below it, owing to the degradation of the soil, by long exposure to the effects of rain and drainage.

Terraces are universal. They are more bold and steep in the upper or boulder member (No. 3), but characterize them all. Parallel ridges of sand and gravel are generally due to a modification of the drift during the changes which occurred toward the close of the ice-period. Osars are of the same origin.

On the height of land south of Lake Erie there are in the upper member numerous depressions like hillocks or osars *reversed*, which I have designated as "drift cavities." As we proceed northward and westward these cavities are more marked and abrupt. Along the highland west of Lake Michigan they are as steep as the earth and gravel will stand, and are called "potash kettles." They exist along the sources of the streams, at an elevation of 300 to 500 feet above the lake, from the south boundary of Wisconsin to the sources of the Oconto river. I have observed them also to the north-west of Lake Superior. There are places where the total thickness of the drift formation reaches 800 to 1000 feet; but there is no uniformity in the thickness of the different members. The elevation of the most prominent drift summits is very nearly uniform, ranging from 1200 to 1600 feet above the ocean. But the most interesting phenomena connected with the superficial deposits is the universal presence of striæ, grooves, hollows, and warped surfaces, wrought upon the indurated rocks beneath.

Throughout the entire Lake Country, wherever the rocks are capable of resisting the action of water and the atmosphere, they are worn smooth by some resistless mechanical force. On the very imperishable beds, like quartz, magnetic iron, and trap, the lines are still fresh and sharply cut; some of them very fine, like the work of a graver.

In places there are long parallel troughs, from an inch or two to eight and ten inches deep. The compact limestone strata are polished, as though they had been subject to the worker in marble, only there are some scratches not obliterated. Hard, rocky projections are rounded off into domes, which are smooth, with parallel and curved lines engraved on them. The low rocky islets, which barely rise above water level, and the highest summits are shapen into the same form, by the same agents. I have constructed an outline map of the Lake Country with a view to exhibit the extent and the parallelism of these lines. [See author's map of the Lake Country.]

In addition to my observations upon the bearing of these striæ, I have resorted to the reports of surveys in the adjacent States and Canada. Most of the arrows are fixed by using the average of several measurements within a space selected arbitrarily. This average was determined by selecting a tract, of the size of a county or more, where the bearings lie within the same quadrant; adding them together, and thus obtaining an approximate mean. It is impracticable to put each observation upon a map of reasonable size.

The direction of the arrows shows a remarkable uniformity in the direction of the glacial movement. It was almost everywhere from north to south. In the Eastern States, where the mountains rise to 5000 and 6000 feet above ocean level, it was modified by them, acting as obstructions, and turned aside into the valleys. Thus, in the State of Maine the general course coincides with the valley of the Kennebec, and in Massachusetts with that of the Connecticut.

In the basin of Lake Champlain it was not uniform. One group of lines in the neighborhood of this lake agrees with the resultant lines along the Hudson river, all following the course of the great valley which extends from the St. Lawrence, southerly, to the ocean at New York. On the highlands of Vermont and north-western Massachusetts the general bearing is more to the east, crossing the ranges of mountains.

I am not advised of glacial etchings upon the mountains of New England and New York at a greater elevation than 3000 feet. The Adirondacks are the counterpart of the mountains of New Hampshire and Vermont, rising to about the same elevation, and causing local changes of direction in the progress of the ice-mass.

The same general topographical features must have characterized the northern part of the United States during the drift era as at present. If that period should return, and the country should be again enveloped with a covering of ice and nevé, rising to a height of 2000 and 3000 feet, it would meet with the same obstructions and be turned into the same valleys.

On the north of the St. Lawrence the mountains do not attain the height of the New England ranges, and the movement would not meet with sufficient obstacles to change its course materially. It is the same throughout the country farther west, to the lower ranges of the Rocky Mountains. The highest land at the sources of the streams around Lake Superior is less than 2000 feet above tide. At the sources of the Mississippi it nowhere exceeds 1700 feet.

Throughout Michigan, Wisconsin, and Iowa, there is very little land where the most elevated point exceeds 1200 feet. After passing the northern end of the Alleghanies, near the southern boundary of New York, there are no obstructions which a glacier of 2000 feet in thickness might not override till it should pass the Mississippi river 500 to 600 miles. I accept the explanations of Agassiz and Desor, derived from their observations on the Alps, and of Drs. Hayes and Rink, in Greenland, as sufficient in reference to the fact of movement in all fields of ice and nevé. This motion is always towards the point of least resistance.

When the fact of a glacial era in North America is established, these observations determine the fact of motion throughout the entire mass. The ice-etchings are found to have a southern limit, and this corresponds with the southern limit of the boulders or errated rocks.

This southern boundary of the ice-field is somewhat irregular, but its general course in the Mississippi valley is like that of the isothermal lines, north-westerly and south-easterly, bearing to the north as one proceeds westward. If the poles of the earth then held the same position as now, the parallels of equal temperature should have been oblique to the meridian, as they are at present.

In Greenland, the sea, by its higher temperature along the coastline, dissolves the outer edge of that continental field of ice. In this direction there is less resistance to the expansion of the mass, and motion is the result.

During the ice-period in the valley of the St. Lawrence the ocean performed the same office as it does in Greenland now. If a line is drawn from north-east to south-west through the southerly part of Lake Huron, in the country easterly of such a line the general course of the striæ is to the south-east or east of south.

This was not caused by a central chain of elevated land, from which the icy mass descended by gravity; for, unless there have been changes of level, the highest land was between the St. Lawrence and the sea. The north-easterly line through Lake Huron, along which the direction of the striæ changes from south-westerly to south-easterly, passes over a country lower than the New England mountains. It is also nearly parallel to the sea-coast opposite. If the ancient coast conformed in its general bearing with the present, we may thus account for a movement which should be approximately at right angles to it. It was, of course, modified by the contour of the country, the mass, of necessity, settling into the lowest grounds, and following the long axis of the depressions.

There might even be two movements over the same space at the same time, as there is in the progress of clouds, at different elevations, carried in different directions. For this reason, the course of the drift-grooves and striæ on the summits of mountains is a better index of the general bearing of the glacial motion than those in the valleys.

Then, the dissolving edge of the ice-fields in the interior, instead of being at the level of the sea, as in the case of Greenland, was almost on the banks of the Ohio. Motion arising from the same causes would be at right angles to the line along which the ice was most rapidly disappearing. The mass in the rear remained more and more solid, according to its distance from the thawing edges, which must be on the side of the equator.

This vast field, extending from latitude 40° and 42° north, acted as a central mountain, from which, if there was any movement, it must be southerly. So far as we have the bearing of the drift striæ, they have a direction which seldom varies thirty degrees from the meridian.

On the upper lakes, the departures from a south-westerly course can, in most cases, be seen to be due to local causes. I have indicated these irregularities by arrows that are shorter than those which point south-westerly, and it can be seen that the south-easterly lines are exceptional.

Along the Keweenaw range of Lake Superior the striæ have on the summits a close parallelism among themselves and with those on Isle Royal and the Iron mountains of Marquette, bearing south 30° to 40° west. But in the gorges which break the Ranges, they are north and south, south by east, and even south-east.

Local variations are also to be expected, if we admit of different rates of motion. If one part of the field progressed faster than another, there must have been lateral movements. Where a thick and solid mass, covering an area equal to a county or a State, should intrude into a field less solid and moving more slowly, it must necessarily push some part of it aside and produce cross striæ.

As a whole, however, the movement over the country surrounding Lake Superior, and as low down as the middle of Lakes Michigan and Huron, was *south-westerly*. It was also nearly at right angles to the line in the Mississippi valley, which indicates the southern limit of the erratic boulders and the drift striæ. Taking out the cases where the direction of the diluvial grooves is modified by valleys, gorges, and mountains, their general bearing is also nearly at right angles to the isothermal lines of that part of the continent.

I conceive it is to this we should attribute their change of direction from *south-easterly* to *south-westerly* in the interior. Judging by the boulders, the southern edge of the ice-field, on the west, extended from near Dayton, Ohio, in a north-westerly course, to and past Dubuque in Iowa. Here, climate produced the same effects as the warmth of the sea. No icebergs could break off and float away as they would upon a coast, but the rays of the sun and a warm land atmosphere coming from the equatorial regions were sufficient to waste away the mass. Large quantities of fresh water would thus be produced, with currents sufficient to move and sort the earthy materials brought forward from the north.

As the encroachment of the ice, in the commencement of the glacial era, must have been very gradual, so must its disappearance have occupied a long period. Both of them may be regarded as geological epochs. There must have been abundant time, during the withdrawal of the universal glacier, for a partial rearrangement of the loose materials. The present valleys must have existed prior to and during this era, but much modified at its close.

Fresh-water shells came into being. Timber which had existed prior to the era of cold would not decay while the temperature was so low, and seeds of preglacial plants might also be preserved. Such animals as did not perish retreated southerly, and when the surface of the earth again became habitable, they resumed their old haunts. The disappearance of the horse, mastodon, and elephant is due to other causes than the cold of the ice-period. Along the retreating edges of the field, the morasses, cavities, and terraces could be produced by the combined action of moving ice and currents of water.

In regard to the cavities in Ohio, Wisconsin, and Minnesota, the first impression upon viewing them is, that patches of ice were enclosed in earth, which afterwards, by thawing out, left the surface in the form of great pits, with a narrow rim between them. While it was disappearing the ice-mass would present, in the interior, a sloping

BEARING OF THE GLACIAL ETCHINGS UPON THE ROCKS ON AND ADJACENT TO THE WATERS OF THE NORTHERN LAKES, IN THE UNITED STATES AND IN CANADA.

| LOCALITY. | KIND OF ROCK. | CONDITION OF THE SURFACE. | BEARING OF THE STRIÆ, FACING SOUTH. | AUTHORITIES. | ELEVATION AND REMARKS. |
|---|---|---|---|---|---|
| UPON AND ADJACENT TO LAKE SUPERIOR. | | | | | |
| Vermillion Lake, | mica slate, | much polished and worn down, | S. 5° E. (true), | Chas. Whittlesey, | rocks bare and moutonnè. |
| Sturgeon Lake, | hornblende slate, | much polished and worn down, | S. 55° W. | Chas. Whittlesey, | about 1100 feet above sea-level. |
| Rainy Lake, | tolcose sla. & granite, | much polished, rocky islets in domes, | S. 40° to 60° W. | Chas. Whittlesey, | numerous observations. |
| Rainy Lake, | tolcose sla. & granite, | much polished, | W. | James Hector, | report of Capt. Palisser. |
| Lake of the Woods, | metamorphic slates, | | S. 30° W. | James Hector, | mean of four observations. |
| Dog Lake, | metamorphic slates, | | S. 10° W. | James Hector, | |
| Lake of One Thousand Isles, | metamorphic slates, | | S. 5° E. | James Hector, | mean of six observations. |
| Passabika River, N. shore, near Superior City, | trap, | distinctly visible, well worn, & polished, | S. 46° W. | Dr. Norwood, | lake-level 605 feet. |
| Wisokada River, W. shore, Isle Royal, | trap, | | S. 25° W. | Dr. Norwood, | |
| Scovill's Point, | trap, | rocks worn into troughs, deep hollows and elevations, | S. 50° W. | Edward Desor, | near lake-level. |
| Ackly Bay, | trap, | excavations, — extensive surfaces, | S. 75° W. | Edward Desor, | near lake-level. |
| Chippeway Harbor, S. shore, Bad River County, Wisc., | trap, | polished furrows & striæ very distinct, | S. 50° W.<br>S. 20° to 25° W. | Edward Desor, | near lake-level. |
| Dalles of Tyler's Fork, | magnetic iron ore, | well polished, striæ fine, | S. 45° E. | Chas. Whittlesey, | follow the direction of the gorge. |
| In gorge, 2 miles west, | quartzite & iron ore, | well polished, striæ fine, | S. 40° E. | Chas. Whittlesey, | follow the direction of the gorge. |
| Sec. 17, T. 44, R. 2, | quartzite & iron ore, | well polished, striæ fine, | S. 55° W. | Chas. Whittlesey, | summit of range 1000 feet above lake-level, or 1600 above tide. The normal direction of striæ. |
| Sec. 24, T. 44, R. 4, | quartzite & iron ore, | well polished, striæ fine, | S. 45° W. | Chas. Whittlesey, | |
| Sec. 20, T. 44, R. 5, | quartz rock, | well polished, striæ fine, | course N. & S. | Chas. Whittlesey, | summit of the range. |
| KEWEENAW POINT. | | | | | |
| Cliff Mine, | crystalline trap, | well polished, striæ fine, | S. 15° W. | Foster & Whitney, | 550 feet above lake-level. |
| Cliff Mine, | crystalline trap, | well polished, striæ fine, | S. 45° W. | Foster & Whitney, | 550 feet above lake-level. |
| Meadow Mine, | amygdaloid trap, | well polished, striæ not deep, | S. 40° W. | Chas. Whittlesey, | 500 feet above lake-level. |
| Phœnix Mine, | amygdaloid trap, | well polished, striæ not deep, | S. 20° to 25° W. | Chas. Whittlesey, | 350 feet above lake-level. |
| Eagle River Mine, | amygdaloid trap, | well polished, striæ not deep, | S. 45° W. | Chas. Whittlesey, | |
| Copper Falls Mine, | conglomerate, | well polished, furrows distinct & parallel, | S. 65° W. | Chas. Whittlesey, | N. slope of range 300 ft. above la.-lev. |
| Copper Falls Mine, | trap, | furrows distinct, | S. 5° W. | S. W. Hill, | 600 ft. above lake-lev., sum. of range. |
| Portage Lake, | trap, | striæ distinct, | S. 40° E. | Chas. Whittlesey, | follows the course of the gorge. |
| Meagher Location, | trap, | | S. 40° W. | Chas. Whittlesey, | |
| Sec. 19, T. 58, N. R. 31, W., | amygdaloid trap, | striæ distinct, and deep trough-like depressions, | S. 20° to 25° W. | Chas. Whittlesey, | summit of range. |

| | | | | | |
|---|---|---|---|---|---|
| OUTONAGON REGION. | | | | | |
| Aztec Mine, | amygdaloid trap, | rocks well smoothed, | S. 27° to 30° W. | Chas. Whittlesey, | summit of range 650 ft. above la.-lev. |
| Ohio Mine, | amygdaloid trap, | rocks well smoothed, | S. 80° E. | Chas. Whittlesey, | vertical sides of gorge polished, the striæ horizontal, — all the rocks rounded by attrition. |
| Adventure Mine, | amygdaloid trap, | rocks well smoothed, | vary from N. 20° E. to S. 88° W. | Chas. Whittlesey, | same as last, striæ covered with red drift clay, and perfectly fresh, their course governed by slope of mountain. |
| MARQUETTE REGION. | | | | | |
| Dead River, | hornblende slate, | trough-like hollows, 2½ ft. wide, 4 ft. deep, | S. 20° W. | Foster & Whitney, | lake-level. |
| Dead River, | hornblende slate, | cross system of striæ, | N. and S. | Foster & Whitney, | lake-level. |
| Middle Island, | granite, | broad troughs, | S. 20° W. | Foster & Whitney, | lake-level. |
| Marquette Landing, | trap, | polished surfaces, warped and trough-like domes, | S. 55° W. | Edward Desor, | lake-level, rocky islets. |
| Carp River, | quartz, | perfectly polished, | S. 20° W. | J. D. Whitney, | 500 feet above lake. |
| Near Carp River, | quartz, | perfectly polished, | S.25° to 30° W. | Edward Desor, | summit of ridge 581 ft. above la.-lev. |
| Near Teal Lake, | specular iron ore, | perfectly polished, | S. 55° W. | Edward Desor, | 750 feet above Lake Superior. |
| Jackson Forge, | specular iron ore, | perfectly polished, | S. 65° W. | Edward Desor, | 1000 ft. above L. Sup., 1605 above sea. |
| Cleve Iron Mine, | specular iron ore, | very distinct, | S. 45° W. | Edward Desor, | also on vertical faces of the rock, as at Adventure Mine. |
| Marquette, | compact trap, | very distinct, | S. 45° W. & S. | Chas. Whittlesey, | lake-level, smooth in troughs, hollows and domes N. side of ledge. |
| CANADA WEST. | | | | | |
| Lake Nipissing, | Laurentian, | distinct and uniform, | S. 45° W. | A. Murry, | Canada Survey. |
| Lake Temiscaming, | Laurentian, | distinct and uniform, | S. 85° E. to S. 86° W. | A. Murry, | Canada Survey, 612 ft. above tide. |
| Glen Creek, | Laurentian, | | N. and S. | A. Murry, | Canada Survey. |
| Allumette Lake, | | | S. 25° E. | A. Murry, | Canada Survey. |
| On Keepin River, | | very distinct, following the course of the valley, | S. 2° E.<br>S. 81° W.<br>S. 4° E.<br>N. and S.<br>S. 15° W.<br>S. 20° E.<br>S. 86° W. | A. Murry, | The glacial lines and furrows cross over points of rocks 35 feet high, rising at an angle of 60° without changing their course. |
| East shore of Lake Huron, | upper silu. limestone, | | S. 45° E. | | Canada Survey. |
| NORTH SHORE OF LAKE MICHIGAN. | | | | | |
| Mackinaw, | upper silurian limestone, | rocks polished in warped surfaces, striæ distinct, | nearly W. | Chas. Whittlesey, | |
| Manitou Point, | upper silu. limestone, | lines distinct, | S.50° to 60° W. | Chas. Whittlesey, | lake-level. |
| Payment Point, | upper silu. limestone, | lines distinct, — well polished, | S.45, 50, 60° W. | Chas. Whittlesey, | lake-level. |
| Marinette, | Trenton lime-rock, | lines distinct, — well polished, | S.40° to 60° W. | Chas. Whittlesey, | lake-level. |

## BEARING OF THE GLACIAL ETCHINGS UPON THE ROCKS, &c. — *Continued.*

| LOCALITY. | KIND OF ROCK. | CONDITION OF THE SURFACE. | BEARING OF THE STRIÆ, FACING SOUTH. | AUTHORITIES. | ELEVATION AND REMARKS. |
|---|---|---|---|---|---|
| Little Osknennesec, Falls Menomonee River, | Azoic slate-silicious, | lines distinct, | S. 70° W. | Chas. Whittlesey, | Elevation of this region 300 to 400 feet above Lake Michigan. |
| Sandy Portage, | Azoic slate-silicious, | lines distinct, | S. 65° to 70° W. | Chas. Whittlesey, | |
| Three miles above Sturgeon Falls, | Azoic slate-silicious, | lines distinct, | S. 65° W. | Chas. Whittlesey, | |
| Tevin Falls, | Azoic slate-silicious, | lines distinct, | S. 60° to 70° W. | Foster & Whitney, | |
| T. 41 N. R. 31 W. Michigan, | Azoic slate-silicious, | lines distinct, | W. | Chas. Whittlesey, | |
| Sec. 10, T. 35 North, Range 19 East, Wisc. | sienite, | roches moutonnè, with quartz seams distinct, | nearly W. | Chas. Whittlesey, | All the summits rounded by glacial action. |
| Oconto River. Sec. 8. T. 28 N. Range N. East, | Trenton lime-rock, | large polished surfaces, striæ not distinct, and crossing each other, | | Chas. Whittlesey, | |
| Oak Orchard, Wisc., W. shore of Green Bay, | Trenton lime-rock, | well polished, | S. 20° W. | Chas. Whittlesey, | lake-level, 583 feet above tide. |
| Desperes, Fox River, | Trenton lime-rock, | well polished, | S. 45° W. | Chas. Whittlesey, | lake-level. |
| Strong's Landing, Fox River, | igneous, | striæ light, | S. 55° W. | James Hall, | |
| Sheboygan Falls, Wisc., | Niagara lime-rock, | extensively polished, several sets of striæ, | S. 55° W.<br>W.<br>N. and S. | Chas. Whittlesey, | covered with a heavy bed of red drift clay. |
| Sheboygan Light House, Lake Michigan, | Niagara lime-rock, | extensively polished in grooves and hollows, | S. 45° W.<br>S. 56° W.<br>S. 35° W. | Chas. Whittlesey, | large polished surfaces, overlaid by red drift clay, lake-level, cleared off by the waves; grooves ½ inch deep, and ¾ in. wide; principal grooves and lines are south-west. |
| Three miles W. of Milwaukee. | upper silurian, | rocks well polished, | S. 60° W. | Desor & Lapham, | |
| OHIO. | | | | | |
| Sandusky City, | upper silurian, | extensively grooved and polished, forming the bottoms of the cellars, — grooves ½ inch deep, | main lines S. 81° W. | Chas. Whittlesey, | near lake-level, 564 ft. above tide; a few feet of earth on the rock; bearing of the striæ vary about 10° from an east and west line, movement easterly. |
| Marble Head. | upper silurian, | deep hollows and warped surfaces, | not given | | lake-level. |
| Kelley's Islands, | upper silurian, | deep hollows and warped surfaces, | N. of E. | | lake-level. |
| Miami River, 7 miles above Dayton, | upper silurian. | well-polished, — lines deep, | S. 19° E.<br>S. 26° E.<br>S. 33° E. | John Locke, | 315 feet above lake-level; grooves deep and straight; soil 2 and 3 ft.; the most southerly obs. etchings. |
| Doylestown, Wayne Co., | coal grit, | striæ distinct, | N. and S. | Chas. Whittlesey, | |
| Akron, Summit Co., | conglomerate, | striæ distinct, | S. 40° W. | Chas. Whittlesey, | 600 ft. above L. Erie, 1164 above tide. |
| Middlebury. Summit Co., | conglomerate, | striæ distinct, | S. 80° W. to W. | Chas. Whittlesey, | |
| Tallmadge, Summit Co., | coal grit, | summit of coal hill, | S. 45° E. | Chas. Whittlesey, | 620 feet above L. Erie; a few feet of soil on the rock, and numerous boulders near by. |

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| Northampton, Summit Co. | conglomerate, | striæ distinct, | S. 80° to 85° E. | Chas. Whittlesey, | |
| Cuyahoga Falls, Summit Co., | conglomerate, | striæ distinct, | S. 45° E. | Chas. Whittlesey, | 450 feet above Lake Erie. |
| Twinsburgh, Summit Co., | conglomerate, | striæ distinct, | S. 40° E. | Chas. Whittlesey, | summit of the hills. |
| Sharon, Medina Co. | conglomerate, | striæ distinct, | S. 40° E. | Chas. Whittlesey, | summit of the hills. |
| Copley, Summit Co., | conglomerate, | striæ distinct, | S. 80° W. | Chas. Whittlesey, | |
| Mantua, Portage Co., | conglomerate, | striæ distinct, | S. 80° to 40° E. | Chas. Whittlesey, | |
| Euclid, Cujahoga Co., | Devonian grit, | striæ very marked, | S. 80° E. | Chas. Whittlesey, | |
| Newburgh, Cujahoga Co., | Devonian grit, | striæ distinct, | N. and S. | Chas. Whittlesey, | |
| Austintown, Mahoming Co., | coal grit, | striæ plain and straight, | S. 80° to 85° E. | Chas. Whittlesey, | summit of the country. |
| Austintown (west part), | lime-rock, | striæ plain, | S. 20° E. | Chas. Whittlesey, | 520 feet above Lake Erie. |
| Weathersfield, Trumbull Co., | coal grit, | striæ plain, | S. 45° E. | Chas. Whittlesey, | |
| Brookfield, Trumbull Co., | coal grit, | striæ plain, | S. 40° E. | Chas. Whittlesey, | |
| Lordstown, Trumbull Co., | conglomerate, | striæ plain, | S. 20° E. | Chas. Whittlesey, | 400 feet above Lake Erie. |
| Palmyra, Portage Co., | coal grit, | striæ plain, | S. 80° to 85° E. | Chas. Whittlesey, | |
| Canfield, Mahoning Co., | lime-rock, | striæ plain, | S. 25° E. | Chas. Whittlesey, | 600 feet above Lake Erie, summit of country. |
| Canfield (west part), | coal grit, | striæ plain, | S. 80° W. | Chas. Whittlesey, | |
| Near New Lisbon, Columbiana Co., | coal grit, | | N. and S. | Morris Miller, | |
| **NEW YORK.** | | | | | |
| Near Rochester, | upper silu. limestone, | | S. 80° W. | N. Y. Geol. Rep'ts, | average of several observations. |
| Valley of St. Lawrence, | lower do. & metamor. | | S. 45° W. | N. Y. Geol. Rep'ts, | average of several observations. |
| Valley of Hudson, | lower do. & metamor. | | S. 5° E. | N. Y. Geol. Rep'ts, | average of several observations. |
| **NEW JERSEY.** | | | S. 45° E. | N. Y. Geol. Rep'ts, | average of numerous observations. |
| **MASSACHUSETTS.** | | | | | |
| Valley of the Connecticut, | | | S. 80° 15′ E. | Prof. E. Hitchcock, | mean of 182 observations. |
| Near Boston, | | | S. 20° E. | Prof. E. Hitchcock, | mean of numerous observations. |
| **VERMONT.** | | | | | |
| Valley of Lake Champlain, | | | S. 50° E. | Geological Survey, | mean of numerous observations. |
| North line of State, | | | S. 20° W. | Geological Survey, | mean of numerous observations. |
| **MAINE.** | | | | | |
| Valley of Kennebeck, | | | S. 15° E. | Geological Survey, | mean of numerous observations. |

and not a mural front, giving a greater southerly slope to the surface than it now possesses.

This would facilitate the local southerly flow of water, which otherwise, in a country so nearly level, would be very slow. From the source to the mouth of the Mississippi, it is less than one foot in a mile.

The highest land along the line of dissolution should reappear first. Ridges of 300 to 500 feet elevation might thus be bare, while there were around the base and sides ice-masses still being pushed along towards the south. There are high terraces, particularly those composed of large boulders, which suggest the idea of such a state of things.

I attempt no explanation of the singular fact, that the fossils of the drift, from the easterly part of Lake Ontario to the ocean and beneath it, are of marine and not fresh-water origin. Sir Charles Lyell found them near Montreal, at an elevation nearly equal to that of Lake Erie. They are abundant at Ogdensburg and on Lake Champlain, in the drift clays almost on a level with Lake Ontario.

There is no evidence of a rise in the land along the lower St. Lawrence, and the valley of the Hudson since the ice-period. How marine and fresh-water shells should occupy the same horizon, without changes of level, is a question of interest for discussion. No present barrier exists between the fresh and salt water shells. An uniform settling of the land, so as to bring the summit of Montreal mountain to the surface of the sea, would let it into Lake Superior.

## 2. ON THE LAURENTIAN LIMESTONES AND THEIR MINERALOGY.

By Dr. J. STERRY HUNT, F. R. S.

[Abstract.]

THE author alluded to the existence, in the Lower Laurentian system, of three limestone bands, or formations, of great but variable thickness, which might fairly be compared with the great limestone groups of the North American palæozoic system. In addition to these, there is probably a fourth and newer limestone formation belonging to the Lower or true Laurentian, besides one or more in the unconform-

able overlying Labrador series, or Upper Laurentian. The three limestone formations first named are separated by great masses of gneissic and quartz ore strata, and are intimately associated with beds in which silicates of lime and magnesia prevail, together with graphite and various metallic ores. The minerals associated with these limestones and their accompanying strata were next considered, and it was shown that they occur both disseminated in the beds and filling fissures or veins which traverse the strata. The importance, in a geological point of view, of these veinstones, which, from their mode of formation, might be named endogenous rocks, was insisted upon. They may attain very great dimensions, and may include any or all of the mineral species belonging to the adjacent stratification, variously grouped, and sometimes having a banded arrangement parallel to the walls of the vein. Among the characteristic minerals of these veins are calcite, apatite, pyroxene, hornblende, serpentine, chondrodite, othoclase, scapolite, phlogopite, quartz, garnet, idocrase, epidote, spinel, corundum, sphene, zircon, magnetite, and graphite. Some of these, occasionally occur in a nearly pure state, filling the veins, as graphite, pyroxene, and apatite. Veins of crystalline carbonate of lime, generally including some one or more of the preceding minerals, are often met with, and it is these which have given rise to the notion maintained in this country by Emmons, and in Europe by Leonhard and others, that crystalline limestone is either partially or entirely of eruptive origin; these calcareous veinstones having been confounded with intrusive dykes. From such veinstones a transition may be traced to those in which orthoclase and quartz prevail, often to the exclusion of lime and magnesia compounds; we have then true granitic veinstones in which tourmaline, beryl, and muscovite, cassiterite, and columbite are sometimes met with. These endogenous rocks, in which are often concentrated the rarer chemical elements of the rocks, are to be carefully distinguished from intrusive dykes which are seotic rocks.

Such veins are not peculiar to the Laurentian system, but are found in crystalline strata of various ages. The crystalline limestones of Scandinavia, which offer so many remarkable resemblances to those of New York, New Jersey, and Canada, are, however, of Laurentian age, and the nature of their veins has been well understood by Scheerer.

The rounded angles of crystals of certain minerals from the calcareous veins of the Laurentian system, especially of the crystals of apatite and quartz, which Emmons had supposed to be due to a commencement of fusion, is to be regarded as the result of a partial resolution of the previously deposited crystals, and as marking a stage in the progressive filling of the veins. Crystals of orthoclase, pyroxene, sphene, and zircon, though accompanying these rounded crystals, retain the sharpness of their angles because of their permanence in the heated alkaline solutions which had circulated through these yet partially filled veins.

The various minerals of these veinstones have been deposited from aqueous and saline solutions at elevated temperatures, and the experiments of Daubrée and of De Senarmont, and the microscopic observations of Sorby, support this view. Plutonists begin to understand that water cannot be secluded from rocky strata, but is all-pervading, and that at great depths, kept by pressure in a liquid state at an elevated temperature, and having its solvent powers augmented by alkaline salts, it plays a most important part in metamorphism and the formation of veinstones. The author supposed, with Mr. Hopkins, that in earlier geological periods the increase of temperature in buried strata was far more rapid than at present, so that great heats prevailed at comparatively small depths from the surface, and produced great chemical and molecular changes. The temperatures at which the various silicated and other minerals, including graphite, had been dissolved from the strata and crystallized in the veins, he supposed to have been, judging from various analogies, between the melting-point of tin and low redness.

The distinction between the apatite, graphite, and magnetite, disseminated in the beds, and the same minerals in the veins, was particularly insisted upon.

As to the origin of the principal silicious minerals of the limestones, such as serpentine, chondrodite, pyroxene, rensselaerite and loganite, Dr. Hunt regards these as having been directly deposited as chemical precipitates from the seas of the time, and cites the example of the Eozoön Canadense, an abundant fossil of the time, found imbedded in these silicates, which enclose it and fill the minute pores of its calcareous skeleton. To a similar chemical precipitation he attributes the serpentines, talcs, chlorites, and epidolites, which occur in more recent rocks, and may be found in their incipient state before the metamorphosis of these rocks, which has, for the most part, only crystallized and re-arranged the already-formed amorphous silicates. The chemical agencies which gave rise to these silicates of lime, magnesia, iron, and alumina were briefly discussed and declared to be still active, although, probably, to a less degree than formerly.

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## 3. SECTION OF THE ROCKS IN EASTERN KANSAS. By G. C. SWALLOW, of Columbia, Missouri.

### SYSTEM I.—QUATERNARY.

### FORMATION *a*—ALLUVIUM.

No. 1.—Soil—Everywhere. 1 to 6 feet.
No. 2.—Sandbars—Missouri and Kansas rivers. 10 to 20 feet.
No. 3.—River bottoms—Sands, clays, pebbles, and vegetable mould or humus—All streams. 20 to 30 feet.

### FOMATION *b*—BOTTOM PRAIRIES.

No. 4.—Sands, clays, and marls—Large streams. 25 to 30 feet.

### FORMATION *c*—BLUFF.

No. 5.—Silicious marls and sands—On all the highlands under the the soil. 1 to 150 feet.

### FORMATION *d*—DRIFT.

No. 6.—Sands, pebbles, and boulders—Generally distributed under the strata above-named, and resting upon the consolidated strata below. 1 to 20 feet.

### SYSTEM II.—TERTIARY.

In Western Kansas, but not yet observed in Eastern Kansas.

## SYSTEM III. — CRETACEOUS.

But partially developed in Central Kansas.

No. 1. — Brown ferruginous, yellow and buff sandstone —Generally classed as cretaceous, but saw no positive proof of its age — Hills south of Kansas river, near the mouth of the Saline. 95 feet.

## SYSTEM IV. — TRIASSIC. (?)

No. 2. — Brown sandy shales and marls, with their beds of earthy carbonaceous matter or impure coal. Locality, same as No. 1. 15 feet.

No. 3. — Brown, red, buff, and gray mottled standstone. Locality, Republican, Smoky Hill, Cottonwood, and Fancy Creek. 75 feet.

No. 4. — Brown, drab, reddish, and greenish marls and shales. Locality, same as No. 3. 32 feet.

No. 5. — Fine buff magnesian limestone in thin, hard beds. Locality, Kansas River and Fancy Creek. 6 to 10 feet.

No. 6. — Red, brown, purple, green, blue, and drab argillo-magnesian marls and shales. Some of these beds are intersected by their calcareous plates crossing each other at angles nearly right, forming a cancellated or chambered structure like the cancellated structure of bones a hundred times magnified; the chambers or cells filled with soft clay and lined with crystals and concretions of lime. Locality, same as No. 5. 50 to 90 feet.

No. 7. — White, granular and dark gypsum and fibrous selenite, with marly shale partings. Locality, Kansas and Gypsum Creek. 42 feet.

No. 8. — Red, blue, drab, and purple marls and shales. Locality, same as No. 7. 36 feet.

No. 9. — White and colored gypsum and selenite, interstratified with various colored marls. Locality, Kansas river. 27 feet.

No. 10.[1]—Bluish and brownish drab shales and cancellated marls. Locality, same as No. 9. 25 feet.

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[1] The sandstones, limestones, shales, marls, and gypsums of Nos. 2-10 were referred to the Triassic with a (?) in 1858. The only evidence we then had of the

No. 11.—Fine, hard, black, porous limestone. Locality, head of Turkey Creek.

## SYSTEM V.—PERMIAN.

No. 12.—Blue, brown, purple, and drab cancellated marls and shales, containing beds of gypsum and selenite. Locality, same as No. 11. 30 to 40 feet.

No. 13.—Fine, hard, buff and drab magnesian limestone in their beds. *Nuculas* and *Bakevellias*. Locality, same as No. 11. 5 feet.

No. 14.—Brownish and bluish drab cancellated marls. Locality, Turkey Creeks and Cotton Wood. 20 to 30 feet.

No. 15.—*Cancellated Limestone.* Similar in structure to the marls, No. 6, *Bellerophons*. Locality, same as No. 14. 3 to 10 feet.

No. 16.—*Concretionary Limestone.* This is a yellowish drab argillo-magnesian limestone in heavy concretionary beds. Locality, same as No. 14. 2 to 15 feet.

No. 17.—*Calcareous Conglomerate,*—not permanent. Locality, same as No. 16. 1 to 24 feet.

Nos. 15, 16, and 17—pass into each other by insensible gradations. They are not often found together, and are all well developed.

No. 18.—Black, porous rock, filled with fragments of fossils, wood and other materials. Locality, Turkey Creek. 6 feet.

No. 19.—Drab cancellated marls, interstratified with blue, green, and purple shales. Locality, same as No. 14.

No. 20.—Greyish-buff, *Cellular Limestone.* Locality, Fancy Creek. 2 feet.

No. 21.—Bluish shale. Locality, same as No. 20. 2 feet.

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age of these beds was the position and lithological characters, and a single fossil which could not be distinguished from *Nucula speciosa*, Munster, from the Muschelkalk of Bindloch. Subsequent examinations have strengthened the evidence we then had that this is the true position of these rocks; but still the proof does not amount to demonstration, and it must remain in doubt till other discoveries determine the matter. Our present knowledge is sufficient for all practical purposes, for we know their exact position in the series of rocks in Kansas, and their valuable mineral contents, and the places where the gypsum beds may be found.

No. 22. — Hard, brown-buff cellular limestone. 4 inches.

No. 23. — Bluish drab shale, with calcareous concretions. 3 feet.

No. 24. — Fine bluish-drab and buff magnesian limestone, full of Permian acephala, and *Cephalopods*. Locality, Fancy and Turkey Creeks, and Cottonwood. 6 feet.

No. 25. — Marly Shales. Locality, same as No. 24. 1 to 5 feet.

No. 26. — Hard, grayish and bluish-buff, porous oolitic limestone, full of minute acephala of Permian types. Locality, same as No. 24. 1 to 2 feet.

No. 27. — Brownish-buff magnesian limestone. Fossils same as last. Locality, same as No. 24. 6 to 12 inches.

No. 28. — Brown, sandy shales filled with *Aviculopecten constens*.. Locality, same as No. 24. 6 inches.

No. 29. — Blue and brown shales. *Aviculopecten constens*. Locality, same as No. 21. 6 to 12 feet.

No. 30. — Buff magnesian limestone. Locality, same as No. 24. 6 inches.

## Lower Permian.

No. 31. — Brown, red, and blue shales. Numerous *Producti*, *Orthisina*, *Athyris*, *Stenopora Crinoids* and *Cynoclodias*. Locality, same as No. 24. 3 to 20 feet.

No. 32. — Soft, impure, brown, porous magnesian limestone. Locality, same as No. 24. 6 to 8 inches.

No. 33. — Blue and drab marls. Locality, Turkey and Fancy Creeks. 1 to 15 feet.

No. 34. — Hard, blue and dark-buff limestone. *Productus Calhounianus*, *Edmondia Hawni*, *Monotis Hawni*, *Myalina*, *Pinna*, etc. Locality, same as No. 33. 1 to 2 feet.

No. 35. — Blue and brown marls, sometimes cherty. Locality, same as No. 33. 1 to 2 feet.

No. 36. — Blue and brownish-drab, hard or soft limestone. *Monotis*, *Schizodus*, *Bakevellias*, *Pinna*, etc. Locality, same as No. 33. 1 foot.

No. 37. — Shales. Locality, Turkey Creek. 7 inches.

No. 38. — Hard, yellowish-drab magnesian limestone, with dark spot, and dendritic markings. *Monotis*, *Pecten*, *Schizodus*, *Avicula*, etc. Locality, same as No. 37. 1 foot.

No. 39. — Blue, brown, green, and red shales and marls. Many fossils, nearly all of carboniferous genera. Locality, Cottonwood, Carey and Fancy Creeks. 30 to 40 feet.

No. 40. — 1st. *Cherty Limestone* — is a brownish-buff magnesian limestone, with cherty concretions. *Productus Calhounianus, Semireticulatus*, (?) *Athyris Subtilita*, (?) *Archæocidaris*. Locality, Cottonwood and Carey Creeks. 4 feet.

No. 41. — Brown and drab indurated marls with chalcedonic geodes. Locality, Cottonwood and Carey Creek. 6 feet.

No. 42. — Buff and bluish-gray and brown, coarse, porous magnesian limestone, showing sun-cracks and ripple-marks. Locality, same as No. 41. *Archæocidaris, Orthisina, Synocladia, Crinoids*, and *Bulanus*.(?) 4 to 12 feet.

No. 43. — Brown and blue marls. Fossils and locality, same as No. 41. 12 feet.

No. 44. — 2d. *Cherty Limestone* — is hard bluish-drab, and very cherty. *Productus, Myalina*, and *Spirifer*. Locality, same as No. 41. 4 feet.

No. 45. — Brown marls. Fossils and locality, same as No. 41. 8 feet.

No. 46. — Brown and buff cellular limestone. Locality, same as No. 41. 1 foot 6 inches.

No. 47. — Brown, blue, purple, and green shales and marls. *Archæocidiris, Athyris*, and *Crinoids*. Locality, same as No. 41. 42 feet.

No. 48. — Bluish-buff and brown magnesian limestone. Permian *Acephala*. Locality, Carey and Fancy Creeks. 13 feet.

No. 49. — Brown, blue, green, and drab marls and shales, with a few thin beds of limestone. *Thamniscus dubius*, (?) *Monotis Hawni*, etc. Locality, Carey Creek. 41 feet.

No. 50. — Drab and buff magnesian limestone. Permian Fossils — Locality, same as No. 49. 9 feet.

No. 51. — Blue and brown shales and marls. *Athyris* like *Subtilita*. Locality, same as No. 49. 12 feet.

No. 52. — *Fort Riley Limestone*. — This is a buff, porous magnesian rock, in thick beds. *Productus Calhounianus, Othisina, Shumardiana Archæocidaris*, and *Bakevellia*, etc. Locality, near Fort Riley, Cottonwood, Blue and Fancy Creeks. 8 to 10 feet.

No. 53. — Blue and brown shales. Locality and fossils, same as No. 52. 6 feet.

No. 54. — 3d. *Cherty Limestone* is light-buff and magnesian. Locality, same as No. 52. *Producta Calhouniana*, *Archæocidaris*, *Spirifer* like *Lineatus*, *Orthisina* like *Umbraculum*. 40 feet.

No. 55. — Brown, blue, and red shales and marls. Locality and fossils, same as No. 52. 20 to 35 feet.

No. 56. — *Myalina Limestone* is a brownish-gray and buff magnesian limestone. Numerous *Myalinas* of Permian forms. Locality, same as No. 52. 4 to 8 feet.

No. 57. — Blue, brown, and red marls and shales. Locality and fossils, same as No. 52. 10 to 25 feet.

No. 58. — 4th. *Cherty Limestone* is brown, buff, and porous cherty magnesian limestone. Locality, sand fossils nearly, the same as No. 54. 10 to 24 inches.

No. 59. — Blue, drab, and brown marls and shales. *Orthis*, *Chonetes*, *Arca*, and *Crinoids*. Locality, same as No. 52. 8 to 21 feet.

No. 60. — Thin sandy argillo-calcareous shales, full of Permian *Acephala*. Locality, near Fort Riley. 3 feet.

No. 61. — Bluish-brown shales. *Chonetes* and *Productus*. Locality, same as No. 60. 3 feet.

No. 62. — 5th. *Cherty Limestone* is a light drab and buff cherty magnesian limestone. *Productus Calhounianus*, *Chonetes*, *Mucronata*, *Orthisina* like *Umbraculum*, *Athyris* like *Subtilita* and *Crinoids*. Locality, same as No. 60. 12 feet.

No. 63. — Brown, bluish-drab, green and purple shales and marls. *Synocladia biserialis*, *Productus Norwoodi*, *Orthisina Shumardiana*, etc. Locality, same as No. 60. 11 to 23 feet.

No. 64. — Impure brown, porous limestone, with dark dots and dendritic markings. Locality, same as No. 60. 4 feet.

No. 65. — Blue and brown marls and shales. Locality, same as No. 60. 15 to 30 feet.

No. 66. — Light buff and drab argillo-magnesian limestone, in thin beds, with dark dendritic markings — *Monotis* and *Bakevellia*. Locality, same as No. 60. 15 to 18 feet.

No. 67. — Blue and drab shales and marls. Locality, same as No. 60.

No. 68. — Hard blue and buff magnesian limestone, containing numerous Permian *Acephala*. Locality, Cottonwood and Clark Creek. 1 to 3 feet.

No. 69. — Drab shaly marls. 5 feet.

No. 70. — Hard blue and drab mottled porous limestone. 1 foot 6 inches.

No. 71. — Brown, blue, and reddish marls. Locality, Clark Creek. 5 feet.

No. 72. — Bluish-gray limestone. Locality, Clark Creek. 3 inches.

No. 73. — Brown and purple mottled shales. 7 feet.

No. 74. — Hard, brown and blue limestone. 10 inches.

No. 75. — Blue shales. 5 inches.

No. 76. — *Coraline Limestone*. Soft blue and gray limestone. *Monotis Halli* and *Americana*, *Productus Norwoodi*, *Synocladia*, *biserialis*, *Thamniscus dubius*, (?) *Edmondia Hawni*, *Phillipsia Cliftonensis*, etc. Locality, Cottonwood and Clark Creek. 3 feet.

No. 77. — Blue, brown, and purple shales and marls. Locality, same as No. 76. 9 feet.

No. 78. — Gray and drab porous limestone. Locality, same as No. 76. 2 feet.

No. 79. — Blue, brown, and purple marls, some very much cancellated and a few beds of thin limestone. *Chonetes*, *Productus costaloides*, *Orthisina Missouriensis*, *Synocladia biserialis*, *Archæocidaris* and *Euomphelus*. Locality, same as No. 76. 38 feet.

No. 80. — *Fusulina Limestone*, buff, porous, and magnesian. *Productus*, *Chonetes*, *Allorisma*, *Fusulina*, etc. Locality, Manhattan, Cottonwood Falls, and Mill Creek. 6 feet.

No. 81. — Blue, brown, purple, and green shales and marls, with calcareous concretions and thin consolidated strata. *Monotis*, *Edmondia*, *Myalina*, *Pecten*, *Allorisma*, and *Bellerophon*, nearly all Permian types. 31 feet.

No. 82. — *Cotton Rock*, a light cream colored argillo-magnesian limestone, sometimes in thin beds with shale partings. It has numerous dendritic markings. *Spirifer*, *Athyris*, *Fusulina*, *Productus*, and *Crinoids*. Locality, Manhattan and Mill Creek. 5 feet.

No. 83. — Bluish-brown marls. 1 foot.

No. 84. — "*Dry bone Limestone*" — brown concretionary and cancellated limestone. *Synocladia biserialis*, *Spirifer planoconvexa*, etc. 5 to 15 feet.

Nos. 82, 83, and 84 are sometimes represented by a bluish-gray and buff porous magnesian limestone, upper beds thick, below thin beds separated by cellular partings, containing numerous Permian *Acephala* and *Zaphrentis* and small *Spirifer*. Locality, Cottonwood.

## SYSTEM VI.—CARBONIFEROUS.

### F *a*—COAL MEASURES.

No. 85.—Brown indurated and cancellated marls. *Spirifer planoconvexa* and *cameratus* (long variety), *Fusulina*, etc. Locality, Manhattan and Cottonwood. 2 feet six inches.

No. 86.—Hard buff and gray limestone filled with fragments of fossils. Locality, same as No. 85. 1 foot 3 inches.

No. 87.—Buff, brown, and blue marls and shales. 8 feet.

No. 88.—Impure, soft brown and buff argillo-magnesian limestone. Locality, same as No. 85. 5 feet.

No. 89.—Brown shaly marl. 1 foot.

No. 90.—Blue and brown mottled limestone. 1 foot.

No. 91.—Brown, drab, green, and purple marls and shales. *Retria punctilifora*, *Monotis*, and *Edmondia*. 19 feet.

No. 92.—Fine drab magnesian limestone. 10 inches.

No. 93.—Blue, green, drab, brown, and purple shales and marls; sandy shales near top and black slate near bottom. *Athyris subtilita*, *Archæocidaris aculeatus*. Locality, same as No. 85. 38 feet.

No. 94.—Brown sandy shales. Locality, same as No. 85. 6 feet.

No. 95.—Brown calcareous sandstone with crystals of calc-spar. Locality, Manhattan. 3 to 4 feet.

No. 96.—*Fusulina Shales*. Dark-blue marly shale. Numerous *Fusulinas* and *Carboniferous Brachiopoda*. Locality, Manhattan, Cottonwood and Mill Creek. 12 feet.

No. 97.—Black Slate. *Fish scales* and *Discina Missouriensis*. 1 foot.

No. 98.—Coal. Locality, Manhattan and Mill Creek. 1 to 3 inches.

No. 99. — Impure brown limestone. *Fish teeth.* 1 foot.

No. 100. — Blue and brown shales. 5 feet.

No. 101. — Impure buff magnesian limestone. Many *Fusulinas.*

No. 102. — Blue, brown, and purple shales. 25 feet.

No. 103. — Hard blue limestone. *Productus* and *Crinoids.* 1 foot.

No. 104. — Black, brown, and blue shales. 2 feet.

No. 105. — Impure bluish-brown limestone. *Hydraulic*, *Productus*, *Chonetes*, *Spirifer*, and *Orthisina.* 10 inches.

No. 106. — Blue, brown, and purple marls and shales, some sandy shales in thin strata. Locality, same as No. 98. 35 to 43 feet.

No. 107. — Hard, drab, bluish and porous magnesian limestone. Permian *Acephala.* (?) 2 to 3 feet 6 inches.

No. 108. — Drab, blue and greenish marls, often filled or replaced by black, white, buff and yellow selenite. Locality, same as No. 98. 1 foot 6 inches.

No. 109. — Impure dark-brown shaly limestone. *Carboniferous fossils.* 6 inches.

No. 110. — Dark-blue and drab shales. 2 feet.

No. 111. — Impure shaly limestone. *Fucoids.* 10 inches.

No. 112. — Blue shale. 1 foot.

No. 113. — Coal. 1 to 3 inches.

No. 114. — Blue shale. 2 feet 6 inches.

No. 115. — Oxide of Iron — Local. 3 inches.

No. 116. — Impure brown magnesian limestone. 1 foot.

No. 117. — Blue and brown argillo-arenaceous shales and marls. Locality, same as No. 98. 17 feet.

No. 118. — Blue and brown impure limestone. (*Hydraulic.*) 1 foot 8 inches.

No. 119. — Blue, brown, and black shales. 9 feet.

No. 120. — Blue and drab magnesian marls, containing crystals of black selenite. Numerous *Acephala* and *Cephalopoda.* Some like Permian types. Locality, Zeandale, and Mill Creek. 15 feet.

No. 121. — Hard, crystalline, grayish-blue limestone, with black dots and dendritic markings. Numerous small *Acephala* and *Cephalopoda.* Some like Permian types. Locality, same as No. 120. 2 to 10 inches.

No. 122. — Blue, drab and brown magnesian shales. Fossils and locality, same as No. 120. 6 feet.

No. 123. — Hard, fine, reddish-brown and gray spotted limestone. 2 feet.

No. 124. — Drab, blue brown and grayish shales. 4 to 6 feet.

No. 125. — Buff and brown soft argillo-calcareous sandstone. The lower part is calcareo-magnesian, full of chocolate-colored pores and small masses of oxide of iron, — colors and pores arranged in thin strata which separate on exposure. Locality, Mill Creek. 1 foot 8 inches.

No. 126. — Green, drab, and purple shale. 12 feet.

No. 127. — Impure brown porous limestone, and greenish-drab porous marls. *Productus*, *Retria*, *Spirifer*, *Orthisina*. Locality, same as No. 121. 1 to 2 feet 6 inches.

No. 128. — Blue, brown, and purple shales and marls. Fossils and locality, same as No. 121. 33 feet.

No. 129. — Coal. 4 to 10 inches.

No. 130. — Fire clay. 6 inches.

No. 131. — Brown and blue sandstone and shale. Locality, Mill Creek. 21 feet.

No. 132. — Impure brown and greenish-gray hydraulic limestone. *Productus*, *Chonetes*, *Pinna* and *Fusulina*. Locality, same as No. 131. 1 foot 3 inches.

No. 133. — Blue argillaceous and sandy shales. 6 feet.

No. 134. — *Chætetes Limestone.* This is a fine, hard, porous, impure limestone, varying in color from gray through ochreous brown to chocolate. The lower part is firm and brown, and the upper beds are blue and argillaceous. *Fusulina*, *Myalina*, *Zaphrentis*, *Crinoids* and a *Chætetes* in irregular masses, or formed around a *Zaphrentis* or a *Crinoid* column. Locality, Mill Creek and Eastward.

No. 135. — Brown and blue shales and marls, with calcareous concretions and bands of kidney ore. Locality, same as No. 134. 45 feet.

No. 136. — Brown and bluish-gray limestone in one bed. *Chonetes* and *Crinoids*. Locality, same as 134. 1 foot 8 inches.

No. 137. — Blue and brown shales. 10 feet.

No. 138. — Hard, dark, ochreous, brown limestone Locality, near Baptist Mission. 2 feet.

No. 139. — Shale. Locality, same as No. 138. 5 feet.

## CHOCOLATE LIMESTONE SERIES.

No. 140. — *Chocolate Limestone.* This is a coarse, rough, porous gray and chocolate limestone, full of a very large ventricose *Fusulina*, *Productus Americanus*, *Calhounianus* and *cora*, *Zaphrentis* and *Crinoids*. Locality, Mill Creek and Eastward. 6 feet.

No. 141. — Blue and brown sandy shales. Fossils and locality, same as No. 140. 11 feet.

No. 142. — Thin, brown, impure limestone and calcareous sandstones, with shale partings. Locality, Verdigris Falls and west of Baptist Mission. 8 feet.

No. 143. — Purple and blue shales. Locality, same as No. 142. 18 feet.

No. 144. — Brown micaceous sandstone. 3 feet.

No. 145. — Blue, drab, red and gray limestone, passing into sandstone. Numerous *Corals* and *Brachiopoda.* 8 feet.

No. 146. — Brown shales. 3 feet.

No. 147. — Bituminous shale. 4 feet.

No. 148. — Gray, buff and brown limestone, passing into brown sandstone below in some places. Numerous *Corals* and *Brachiopoda.* 9 feet.

No. 149. — Brown shales and sandstones. Numerous *Corals* and *Brachiopoda.* 9 feet.

## STANTON LIMESTONE SERIES.

No. 150. — *Stanton Limestone.* Rather coarse drab magnesian and brown limestone. *Productus Americanus*, *Athyris Subtilita*, and *Archæocidaris*, etc. Locality, Mission Creek, Marais Des Cygnes, and Verdigris. 6 to 28 feet.

No. 151. — Argillaceous shales and sandstones. Locality, Marais Des Cygnes and Verdigris. 8 feet.

No. 152. — Blue pyritiferous shales. Locality, Verdigris. 9 feet.

No. 153. — Bituminous coal. Locality, Marais Des Cygnes and Verdigris. 1 foot to 2 feet 6 inches.

No. 154. — Gray and brown sandstone and shales. Locality, same as 158. 12 to 50 feet.

## Cave Rock Series.

No. 155. — *Cave Limestone.* Bluish-gray and brown jointed limestone, with marly partings in places. *Spirifer hemplicata, Productus, Athyris, Crinoids,* etc. Locality, Beaver Creek, Sugar Creek, and Lecompton. 15 to 30 feet.

No. 156. — *Einstein Sandstone* is a blue, brown, and gray sandstone and shale. Locality, same as No. 155. 45 to 60 feet.

## Spring Rock Series.

No. 157. — Gray limestone, spotted with brown in thin irregular beds. Locality, same as No. 155. 2 feet.

No. 158. — Sandstone and shales. Locality, same as No. 156. 15 to 25 feet.

No. 159. — Coal. Locality, Bull and Middle Creeks, Miami County. 4 to 8 inches.

No. 160. — *Fire Clay.* Locality, same as No. 159. Nos. 158, 159, 160 are often replaced by a bluish-brown shale, filled with calcareous concretions. 4 feet.

No. 161. — *Spring Rock.* A hard bluish-gray and brown limestone. Locality, Beaver Creek, Marais Des Cygnes, and Johnson's Creek, west of Topeka and Lecompton. 1 to 4 feet 8 inches.

No. 162. — Brown sandstones and blue shales, interstratified. Locality, same as No. 161. 4 to 38 feet.

No. 163. — Bituminous coal. Locality, West of Baptist Mission, at Johnson's coal bed, west of Topeka. 6 in. to 1 foot 6 in.

No. 164. — Fire clay. Locality, same as No. 161. 1 foot.

No. 165. — Blue shales and brown sandstones, and bands of kidney ore. Locality, West of Baptist Mission, at Lecompton, and Beaver Creek. 35 feet.

### WELL ROCK SERIES.

No. 166. — Blue and gray limestone and porous chert, in thin beds interstratified with shales. *Spirifer* and *Productus*, *Athyris*, etc. Locality, Lecompton, Middle Creek, and Marais Des Cygnes. 5 to 7 feet.

No. 167. — Blue shales. Locality, same as No. 166. 13 feet.

No. 168. — *Well Rock.* — Light-gray and hard brown limestone, with cherty concretions. When fully developed the upper part is coarse and porous, in heavy bands, numerous *Corals* and *Brachiopoda.* Locality, Paris, Lawrence, Garnett, Ottawa, and Leavenworth. 10 to 48 feet.

No. 169. — Brown and blue shales and fine bluish-gray limestone, interstratified (in places all shale). *Productus*, *Chonetes*, *Spirifer*, *Corals*, and *Crinoids.* Locality, same as No. 166. 2 to 6 feet.

No. 170. — Bituminous shale. *Discina* and *Turbo.* Locality, same as No. 166. 6 feet 6 inches.

No. 171. — Hard, firm, blue limestone. *Spirifer lineatus.* Locality, same as No. 166. 1 to 3 feet 3 inches.

No. 172. — Blue and brown shales. Locality, same as No. 166. 1 to 4 feet.

No. 173. — Brown and gray cherty limestone, with shale partings. Numerous *Corals* and *Brachiopoda.* Locality, same as No. 166. 10 to 15 feet.

No. 174. — Blue and brown shales and brown and gray shales and sandstones, with bands of iron ore. Locality, same as No. 166. 75 to 100 feet.

No. 175. — Bituminous coal. Locality, Center Creek, west of Lawrence. 1 to 5 inches.

No. 176. — Brown, green, and purple shales and marls, and buff and gray sandstones. Locality, same as No. 166. 55 to 90 feet.

### MARAIS DES CYGNES COAL SERIES.

No. 177. — Hard, fine, blue limestone, with jointed structure, *Spirifer lineatus*, *Athyris subtilita* and *Crinoids.* Locality, Sugar and Mine Creeks, Linn Co. 2 to 4 feet.

No. 178. — Brown sandstones, and blue shales, and bands of iron ore. Locality, same as No. 177. 38 to 51 feet.

No. 179. — Bituminous coal. Locality, same as No. 177. 2 inches.

No. 180. — Blue and black shale. Locality, same as No. 177. 3 feet.

No. 181. — Bituminous coal. Locality, same as No. 182. 1 foot 8 inches to 2 feet 9 inches.

No. 182. — Black shale and fire-clay. Locality, Linn Co. 3 feet.

No. 183. — Impure brown and bluish-gray limestone. *Spirifer*, *Productus*, *Chonetes*, *Myalina*, *Pecten*, etc. Locality, Sugar Creek and Lawrence. 6 feet.

No. 184. — Brown and buff regularly stratified sandstone. Locality, Muddy Creek, Linn Co. 45 feet.

No. 185. — Blue shales and marls. Locality, Mound City and Muddy Creek. 25 feet.

No. 186. — Brown and bluish-gray limestone, with shale partings and numerous fossils. Locality, same as No. 185. 12 feet.

No. 187. — Blue and brown shaly marls. Locality, Marais Des Cygnes and Mine Creek. 2 feet.

No. 188. — Fine, bluish-drab, concretionary limestone. Locality, same as No. 187. 4 feet.

No. 189. — Brown and bluish sandstone and shales.[1] Locality, Marais Des Cygnes and Mine Creek. 45 feet.

No. 190. — Coal. Locality, same as No. 189. 1 foot 6 inches to 2 feet.

No. 191. — Black slate and fire-clay. 2 feet.

No. 192. — Bluish-drab compact limestone, with very large masses *Chætetes*. Locality, Marais Des Cygnes and Indian Creek. 5 feet.

No. 193. — Brown and drab shales, containing numerous concretions. Locality, Mill Creek, in Bourbon Co. 15 feet.

No. 194. — Blue, green, brown, and chocolate shales and marls. Locality, same as No. 193. 30 feet.

No. 195. — Sandy shales. Locality, same as No. 193. 10 feet.

No. 196. — Brown, and dull brownish-drab sandstone in regular beds. *Calamites*. Locality, same as No. 193. 11 feet.

No. 197. — Brown and drab sandy shales. Locality, same as No. 193. 8 feet.

No. 198. — Blue shales, with bands of kidney ore. 17 feet.

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[1] Mine-Creek Lead Mines are in these rocks.

No. 199. — Bituminous and pyriliferous shale. 1 foot.

Nos. 193–199 are represented by 45 feet of blue and brown shales, with bands of kidney ore on the Marais Des Cygnes, at Root's Coal Bed.

No. 200. — Coal. Locality, same as No. 193 and Marais Des Cygnes, and Mound City. (?) 2 to 3 feet.

No. 201. — Fire-clays and shales. 5 feet.

## PAWNEE LIMESTONE SERIES.

No. 202. — *Pawnee Limestone*[1] is heavy-bedded, porous and compact, coarse and fine, drab, brown and bluish-gray, cherty, concretionary and mottled. *Chætetes* and *Crinoids*, etc. Locality, Indian and Pawnee Creeks, and south to Bone Creek. 20 to 55 feet.

No. 203. — Dull, brownish-blue, hydraulic, concretionary limestone, with pyriliferous shale partings. Locality, same as No. 202. 6 feet.

No. 204. — Black slate. *Discinas*. Locality, same as No. 202. 2 to 4 feet.

No. 205. — Blue and brown argillo-sandy shales. Locality, on the Marmiton, above Fort Scott and Indian Creek. 5 feet.

No. 206. — Impure black shaly limestone full of fossils, and a bed of cone — in cone. Locality, same as No. 205. 6 inches.

No. 207. — Blue and brown argillo-sandy shales, with thin bands of brown limestone and septaria of iron ore. Locality, Indian and Wolverine Creeks. 34 feet.

No. 208. — Black, impure shaly limestone, full of fossils. *Spirifer*, *Productus*, and *Chonetes*. Locality, same as No. 206. 1 foot.

No. 209. — Coal and coal smut. Locality, same as No. 206. 6 inches.

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[1] The lower part of this limestone is almost exactly like the Fort Scott limestone, both in lithological characters and fossils; hence it is very difficult to distinguish them when the upper gray beds of this limestone and the shales below are not exposed. Between Indian Creek and the Marmiton, both of these rocks crop out in the numerous ravines and slopes, and they are very much broken and disturbed, making it almost impossible to make a correct section of the rocks between those streams without this knowledge of the similarity of these limestones.

No. 210. — Brown and blue argillo-sandy shales, with a few bands of iron ore. 25 feet.

### FORT SCOTT COAL SERIES.

No. 211. —*Fort Scott Limestone* is a bluish-drab and brown, irregularly bedded limestone, with many *Producti*, *Chonetes*, and *Spirifers*. Locality, Little Osage, Fort Scott, and south to Dry-wood and Bone Creek, and west to the Neoshe. 8 to 18 inches.

No. 212. — Dark brown shales and marlites and iron-stone. Locality, same as No. 211. 2 feet.

No. 213. — Black slate. Locality, same as No. 211. 4 feet.

No. 214. — Coal. Locality, same as No. 211. 6 inches.

No. 215. — Gray, blue, and brown fire-clays and shales. 5 to 8 feet.

No. 216. — Impure brown and drab hydraulic concretionary limestone in one thick bed. *Productus*, *Spirifer*, *Crinoids*, etc. Locality, same as No. 211. 6 feet.

No. 217. — Black slate containing large concretions of iron-stone. 4 feet.

No. 218. — Coal. Locality, same as No. 211. 1 foot 4 inches.

No. 219. — Fire-clay. 4 feet.

No. 220. — Impure brown mottled limestone. *Spirifer* like *Cameratus* but new. Locality, only on Drywood. 2 feet.

No. 221. — Drab and bluish fire-clays. This bed often passes into sandstone or sandy shales. Locality, same as No. 211. 12 feet.

No. 222. — Blue and brown drab argillo-sandy shales, with sandstone layers and numerous beds of good iron ore. Locality, same as No. 211. 87 feet.

### FORT SCOTT MARBLE SERIES.

No. 223. — Hard, fine, black limestone. Locality, Little Osage, near State line. 3 feet.

No. 224. — Black slate. Locality, same as No. 223. 5 feet.

No. 225. — Blue and yellow shale. Locality, same as No. 223. 7 feet.

No. 226. — *Fort Scott Marble* is black, with numerous yellowish veins and crystallized shells, and it weathers brown. It takes a good polish. Locality, " Slick-Rock Ford," on the Marmiton, and on Moor's Branch above the " Military Ford." 1 foot 6 inches.

No. 227. — Blue and brown shales. 1 foot 8 inches.

No. 228. — Black slate. Locality, same as No. 226. 2 feet.

No. 229. — Coal, good. Locality, Little Osage, below State line. 2 feet 6 inches.

## Lower Coal Series.[1]

No. 230. — Long slope to Middle Fork of Cow Creek, probably sandstone and shale, and two beds of coal, one and two feet in thickness. 25 to 50 feet.

No. 231. — Brown sandstone and sandy shales and iron ore. Locality, Dorsey's, on Middle Fork of Cow Creek. 10 feet.

No. 232. — Brown and bluish argillo-sandy shales, with dark partings. Locality, same as No. 231. 12 feet.

No. 233. — Brown and bluish argillo-sandy shales, with dark partings. Locality, same as No. 231. 12 feet.

No. 234. — Bituminous Coal.[2] Locality, Dorsey's Coal Bank. 5 to 7 feet.

No. 235. — Slope on East Fork, or Little Cow Creek. 10 feet. (?)

No. 236. — Hard, brown and gray sandstone in thick beds, with jointed structure and shale partings. Locality, same as No. 234. 20 feet.

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[1] The south-eastern part of the State, the only place where the lower coal-rocks come to the surface, is so level and the slopes are so gentle, and the soft shales and sandstones are so abundant, that the rocks are but rarely exposed; and the exposures are so small and so far from each other, that it is very difficult to make a connected section with absolute certainty. We could expect to make only an approximation to a connected section in the few days devoted to this interesting region; but, whenever any uncertainty exists in the rocks or their connections, it is fully indicated in the text. If more time could be devoted to this region, a connected section could be made of this important part of the coal series.

[2] We saw but four feet of this coal, as the bank was caved in; but it is reported to be seven or eight feet thick in places.

No. 237. — Sandy and argillaceous shales. 10 feet.

No. 238. — Coal and coal smut. 2 to 6 inches.

No. 239. — Shales and sandstone. Locality, Military Ford, on Cow-Creek. 15 feet.

No. 240. — Red and brown shales with kidney ore. Locality, Shawnee Creek. 20 feet.

No. 241. — Brown, hard, ripple-marked sandstone, with shale partings. Locality, Brush Creek and Mound, 6 miles west of Baxter's Spring.

No. 242. — Blue and brown shales, with black partings and numerous bands of iron ore. Locality, same as No. 241. 35 feet.

No. 243. — Coal and coal smut. Locality, same as No. 241. 2 to 8 inches.

No. 244. — Blue and brown shales. Locality, same as No. 241. 50 feet.

No. 245. — Slope, probably sandstone and shales. 20 to 30 feet.

No. 246. — Brown micaceous sandstone, some irregular, thick, soft beds and some shale partings below. *Calamites.* Locality, Neosho, 3 to 5 miles above State line. 40 feet.

No. 247. — Gray and brown sandstone and kidney ore. Locality, on the Neosho at the State line, and 3 miles above. 2 feet.

No. 248. — Blue shales with black partings, and many bands of iron ore, of which hundreds of tons are washed out on the Neosho, near the State line. Locality, same as No. 248. 12 feet.

No. 249. — Black and gray calcareous shaly limestone, full of fossils. *Productus Chonetes*, *Orthisina*, *Spirifer*, *Corals*, *Crinoids*, etc. Locality, same as No. 248. 8 inches.

No. 250. — Blue and black shale. Locality, same as No. 248. 2 feet.

No. 251. — Coal. Locality, same as No. 248. 4 to 10 inches.

No. 252. — Blue, brown, and black shales. 16 feet.

No. 253. — Space in which the rocks were not seen. 25 feet. (?)

### F *b*. — LOWER CARBONIFEROUS.

No. 254. — Slope covered by fragments of chert and cherty ferruginous conglomerate and clays. Locality, Baxter's Spring and Branch. 10 feet.

No. 255. — Gray and bluish-gray crystalline and granular limestone, with intercallation of chert and hornstone. *Spirifer*, *Productus*, *Chonetes*, *Platycrinus*, and *Zaphrentis:* Oldest rock in Kansas. Locality, Baxter's Spring and Branch to Spring River. 110 feet.

## REMARKS ON THE ABOVE SECTION.

### TERTIARY SYSTEM.

The rocks of this system are known to occupy a considerable portion of Western Kansas; but we have had no opportunity of examining these formations, and therefore cannot give any detailed description of them. The most important fact known respecting this series of rocks is that it contains extensive beds of *Brown Coal*, or *Lignite*, which must be very valuable for fuel in a region possessing so little timber. They crop out along the Smoky Hill, and render that beautiful valley most desirable for agriculture, railroads, and manufactures; whereas, without these beds of fuel, this valley must have remained but sparingly populated for centuries to come.

### CRETACEOUS SYSTEM

Also underlies a large portion of Central Kansas. The ferruginous sandstones, which cap the hills and ridges in Central Kansas, have been referred to this system; whether correctly so must be determined by the examination of localities beyond the range of our explorations during the past year; the cretaceous rocks, however, are known to exist in considerable force in Central Kansas.

### TRIASSIC SYSTEM. (?)

There is a series of buff, red and mottled sandstones, red and drab marls, buff, magnesian and black limestones, blue and brown shales and gypsum, 344 feet in thickness, under the sandstone of the cretaceous (?) and over the rocks known to be Permian. As a sufficient number of fossils had not been found in these strata to fully decide the exact age to which they belong, and as they resembled, in lithological and palæontological characters, the Triassic rocks of Europe more than any others, they were placed promiscuously in that group by Maj. Hawn and myself, in 1858; and as the facts and few imperfect fossils found since rather sustain this classification, it is not deemed advisable to make any change in the arrrangement until future discoveries shall fully establish their position in the geological ages.

It should be remembered, however, that the uncertainty about the age of these rocks does not in the least interfere with our fully understanding the mineral wealth contained in them, nor with our ability to fully develop it; for we know the exact position of these rocks[1] in the series, the strata of which they are made up, and the valuable minerals they contain, and their wonderful fertilizing influence over the soils which rest upon them or come within the range of the waters that flow from them.

These rocks extend in an irregular belt across the State, from the head-waters of the Blue and Fancy, across the Republican and Solomon and over the Kansas, between Turkey Creek and the Saline; thence south and south-easterly up the Smoky Hill and Gypsum, Holland and Turkey Creeks; along the northern slope of the divide, south of the Kansas, to the heads of Lyon and Diamond Creeks; sweeping thence westward across the Cottonwood and down the divide, south of that stream, to the Walnut and White Water.

The gypsum beds in this location are variable in thickness, ranging from 0 to 50 feet. Deposits of pure white gypsum crop out on the Blue, the Republican, and the Kansas, and on Turkey Creek; and on the divides between the Gypsum and Holland, and between Turkey Creek and the Cottonwood. The beds at the four last localities are very thick and miles in length. There are doubtless many other localities between the range of those rocks where these gypsums come to the surface, and which a more careful examination will develop.

## PERMIAN SYSTEM.

There is a series of limestones, marls, shales, sandstones, conglomerates, and gypsums, below the Triassic group described above, which belong to the same age as the Permian Rocks of Europe.

Since the true position of these rocks was first announced[2] in 1858, the proofs of their identity with the Permian system have been constantly accumulating, until at the present time there is probably no geologist who has examined the matter and still doubts their identity with the Permian of Europe.

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[1] See above section, Nos. 2–10.

[2] This discovery was first announced by myself February 22, 1858. See Trans. Acad. Nat. Science, St. Louis. Vol. I.

We have made two divisions of those rocks in reference to the fossils they contain. The upper division comprises the limestones, marls, shales, conglomerates, sandstones, and gypsums in Nos. 12–30 of the section above, representing a thickness of 148 feet. The fossils of these strata, so far as observed, belong to the *Acephala* and *Cephalopoda* and *Gastropoda*, and no one of them has been identified with known Carboniferous species.

In lithological characters these rocks are very similar to the rocks of the same age in Europe. The magnesian limestones and conglomerates, the various colored marls and shales, and the gypsums, all and each would well answer the descriptions given of the same rocks in Europe.

These rocks occupy a narrow belt across the State, east of the Triassic group, as described above.

This formation also contains beds of gypsum, which, together with the marls found in all parts of the series, have a most beneficial influence upon the soils, and will, to a great extent, control the productions, population, and wealth of Central Kansas.

## LOWER PERMIAN.

This series, like the Upper Permian, is made up of a succession of magnesian limestones, blue, drab, red and green marls and shales, red and buff sandstones and conglomerates and gypsums; but there are more blue shales, like those in the coal-measures below. These rocks contain nearly or quite all the fossils found in the Upper Permian, and in addition a few species[1] common to the upper coal-measures, and perhaps a very few not found above or below.

It is a remarkable fact that the Permian and Carboniferous types are seldom if ever mingled in the same stratum, though both occur in thin beds alternating with each other. The Carboniferous forms usually occur in blue argillaceous shales and in the blue limestones, and the Permian in the magnesian and sandy limestones and drab magnesian shales and marls; so that the character of the fossils follows the lithological characters of the rocks in which they occur. Wherever the rocks are of a Carboniferous character we may expect to find fossils of Carboniferous types, and where the rocks are of a Permian character the fossils are also Permian.

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[1] In 1858 I expressed the opinion, based upon the collection sent me by Maj. Hawn, that "although the Permian *species* are so much more numerous, the Carboniferous *specimens* are much the more abundant." But, after a personal examination of these rocks, I am fully satisfied that the Permian fossils are by far the most numerous even in the lowest strata.

The magnesian material and Permian fossils increase towards the south. They are much more abundant on the Cottonwood than on the Kansas and the Blue. Shales and Carboniferous fossils are not so fully developed on the former stream.

A large number of these strata exhibit indications of shoal water in the sun-cracks, ripple-marks, and small piles of fossils and fragments washed together on their surfaces.

These Permian strata so graduate into and are so nearly conformable to the coal-measures below, that no want of conformability can be detected by examining any one locality, though the line of junction be traced a long distance; yet, where sections are made across the line of junction, at distant points, it becomes evident that there is a striking non-conformability. When the sections made across this line on the Kansas, at Manhattan and above, are compared with those on the Blue, though separated several miles, there is no difficulty in identifying all the important strata in one with those in the others, and when these sections are compared with those on Mill Creek, some 25 miles east, and those on the Cottonwood, 60 miles south from Manhattan, the prominent beds are easily identified down to the lowest bed of the Permian, No. 84 of the above section; but Nos. 85–95 from the sections near Manhattan are not found in the Mill Creek sections, where No. 84 rests directly upon the Fusulina shales, No. 96. These facts present a striking illustration in our geology of Prof. Sedgwick's remarks on the Permian of England: —

> "Through many large tracts of country . . . . it (the Magnesian limestone) rests on the coal-measures, and seems to partake of their dip and inclination. It is therefore only after an extensive comparison of the two formations that we can make out their general want of conformity." — (Geological Trans., Vol. III., 2d Sec., p. 56.)

In another paper: —

> "Again, though the lower red sandstone of Yorkshire and Durham appears in some cases to graduate into the coal-measures . . . ; yet, when considered on a great scale, it is unconformable to them, and on that account was separated from them." (Geological Trans., Vol. IV., 2d Sec., p. 397.)

These extracts express the facts as they exist in Kansas, and give one good reason why the line of separation should be made where it is. But the main reason for the separation here is the fact that the Permian fossils come down in force to this line and but few go below; while a few species only of Carboniferous fossils are found above it, and in the shales immediately below there are at least thirty species and millions of specimens.

The rocks also change in lithological characters. The blue shales increase; the limestones are less magnesian and more argillaceous and ferruginous;[1] dark, nearly black, fossiliferous argillo-shaly limestones and thin bands of spathic iron come in; bituminous shales and thin coal-beds begin to appear; and the marls, limestones, and shales below no longer present the marked cancellated structure so characteristic of those rocks above.

## CARBONIFEROUS SYSTEM.

### Coal-Measures.

This formation occupies the surface of nearly all Kansas east of the eastern boundary of the Permian rocks (an area of over 17,000 square miles). This boundary crosses the State in an irregular line from a point on the northern boundary near the 96th parallel, through Manhattan and Emporia, and thence south across the head-waters of the Verdigris and Fall River.

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[1] The magnesian limestones weather white, while the ferruginous become brown on exposure. This change in the color of the surface limestones is very obvious to one passing over the line between these formations. One travelling from the Missouri to Manhattan on the north side of the Kaw, or to near Wabaunsee on the south, over the coal-measures, will find nearly all the limestones brownish; but at those points he will find the limestones in the tops of the hills white, and nearly all between these points and the Triassic sandstones near Salina are of the same color. The same facts may be observed on the Blue, on Mill Creek, on the Cottonwood, and the Verdigris. These changes are so obvious that men unacquainted with geology have observed and mentioned them.

The coal-measures are made up of numerous limestones and sandstones, shales and marls, spathic iron, fire-clay, and coal, Nos. 85, 254, of the above section. These strata lie in a position nearly horizontal, with numerous undulations and a slight general dip to the west, showing no signs of local disturbances save in a few localities. The most important ones observed were between the Marais Des Cygnes to Fort Scott, where the strata are often fractured and tilted up by some forces not now in action.

The lowest of these strata come to the surface in the south-east, and as the country rises to the north-west the higher beds successively come to the surface, resting upon those below until they reach a thickness of 2000 feet,[1] as measured along the outcropping edges. The relative position of these strata may be well illustrated by the courses of shingles on a roof, only the lower shingles should be long enough to reach the ridgepole under the upper layers, as the lower rocks probably do in their western extension.

Nearly all the important beds of limestone become thicker towards the south and east,[2] where they come to and occupy the surface. Towards the west and north these limestones are hard, subcrystalline, bluish-gray, or brown and cherty, and this part of these beds remains very persistent, while the increased thickness to the east and south is produced by the addition of higher massive beds of coarser gray and buff porous magnesian limestones, more or less stained with iron, especially in the pores. These upper beds usually appear as if made up in part of small fragments of fossils and other calcareous matter. They also contain fossils, which run through this portion of all the limestones thus thickened, and are more abundant in them than elsewhere, or even in the lower portions of the same formations. Two or three species of *Archæocidaris* and a large *Athyris* are abundant and *Productus Americanus* more rare in these beds.

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[1] Though this is the measured thickness of the coal strata, they will not be found so thick at any given point, for in the east some of the upper beds are wanting, and in the west, where all are present, they are not so thick as at their outcrops, where the measurements were made.

They cover the surface over an area of 17,000 square feet, and then run beneath the Permian rocks westward.

[2] As an illustration, the thickness of the *Well Rock*, No. 166, is only 10 feet at the Ferry near Lecompton, while on Sugar Creek, in Anderson Co., it is 48 feet. The thickness of the *Stanton Limestone*, No. 151, is only 6 feet at the Baptist Mission in Shawnee Co., but on the Marais Des Cygnes, in Miami, it is 18 feet.

The sandstones and sandy shales are also thicker towards the south-east, and are more generally irregular than any others of these formations, — old beds thinning out and new ones coming in between the more persistent and regular strata of shales and limestones.

These characteristics being so common to the upper beds of so many of the limestones make it very difficult to distinguish these beds from each other and keep the true position of each throughout the vast extent of country over which some of them come to the surface. The *Well Rock* crops out on Sugar Creek, in Anderson Co., as a coarse gray, rough limestone, 48 feet thick, at the ford of the Marais Des Cygnes, on the "Telegraph Road." It is a fine drab compact limestone, 8 feet thick, with an entire new set of fossils. Thence it may be traced from stream to stream and slope to slope, till found near high-water mark at Lecompton, and in the tops of the ridges at Lawrence. This last position it holds in the ridges to Leavenworth, where it is bluish-gray, brown, and subcrystalline.

The coal-beds are also thicker towards the south and east, though there are exceptions; but the most important irregularity observed is the want of persistence or continuity in these beds. Along the eastern edge of this vast coal-field[1] the coal-beds are much more persistent. As a general rule, the south-eastern portion of a coal-bed is more persistent than the north-western, and the lower beds more so than the upper ones. This is one of the reasons why the coal is so abundant and can be found with so much certainty along the eastern outcrop of the lower beds, extending from Fort Gibson to Forts Smith and Scott, and thence across the Osage through Bates, Johnson, and Saline counties in Missouri, and through Boone, Howard, Randolph, and up the Chariton valley into Iowa. Everywhere along this line shafts can be sunk upon the lower coal-beds with an almost absolute certainty of success. But farther west, and along the outcrop of the upper beds, mining operations for coal will be much more precarious.

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[1] This coal-field occupies a large part of the Indian Territory south, all eastern Kansas, the north-western half of Missouri and southern Iowa, and south-eastern Nebraska. Its western boundary extends from a point west of Council Bluffs in an irregular line into Kansas, and thence through Manhattan and Emporium and south to the Verdigris and Fall River.

The geologist can tell with certainty where the rocks containing each coal-bed can be found, and at about what depth; but this irregularity, or want of persistence, in the coal-beds renders it somewhat uncertain whether the coal will be found in its usual place.

But this slight variation from the usual characters in our coal-beds will not much diminish the vast quantity of coal in the State, or render them less important in an economical point of view.

As given in the section of the Coal-Measures, we have discovered twenty-two different beds, varying in thickness from a few inches to seven feet.

Beds of *Carbonate of Iron*, *Spathic Ore*, or *Kidney Ore*, are abundant in the middle and lower portions of this formation.

An examination of the section will show the position of the numerous beds of *hydraulic limestone* and fire-clays which have been discovered.

At one locality, on Mine Creek, a good show of galena was observed in the sandstones and shales of the Marais Des Cygnes Coal Series.

## Lower Carboniferous.

The rocks of this formation consist of chert, cherty-conglomerate at the top, and coarse, gray limestones and hornstones below. They first come to the surface in a branch north of Baxter's Spring, and were next seen at Baxter's Spring and down the branch to Spring River. A thickness of 120 feet was exposed at these places.

This is the lead-bearing limestone of south-west Missouri. The extensive and rich mines at Granby, Centre Creek, and Turkey Creek, east of the State line, are in these rocks, and these deposits and veins of lead may be expected in Kansas as well as in Missouri.

These are the lowest and oldest rocks in the State. They occupy the surface over a small area only in the south-east, and then dip beneath the coal-measures in their extension to the north and west.

## 4. AGAINST THE SUPPOSED FORMER PLASTICITY OF THE PUDDINGSTONE PEBBLES OF PURGATORY, RHODE ISLAND.

By B. S. LYMAN, of Philadelphia.

AT the last meeting of this Association, at Newport, Mr. Charles H. Hitchcock inferred the former plasticity, under metamorphosing influences, of the pebbles of the Puddingstone, at Purgatory, near Newport, from their elongated shape and parallel arrangement and their fitting occasionally into the depressions of each other's surface. I have lately visited the locality, and feel bound to state that I could see in the rock no evidence whatever of the former plasticity of its pebbles. They have, in every respect, the appearance of pebbles on our present shingly beaches, owing their flat shape to the original schistosity of their rocks, and perhaps to the fact that they were, while rolled by the water on the beach, too near the surface of the water to be frequently rolled over and over by it. The parallel arrangement of the pebbles in the rock is but a preservation of their natural position on the beach. Moreover, many of them show their original schistosity, and it is in every variety of direction, instead of being parallel in the different pebbles, as it would be if produced by metamorphism after their deposition as pebbles. The pebbles are in places replaced by sand, making large bodies of false-bedded greenish-gray sandstone, similar to that into which the Puddingstone passes below; a sandstone that is easily cut, and seems to be little metamorphosed, if at all. The whole of the point or ridge between Purgatory and the bathing (or Easton's) beach, westward, is anticlinal in structure, and the Purgatory Puddingstone appears also at the east end of the bathing-beach. A good thickness of the sandstone below appears at the southern end of the point, near the middle of the anticlinal arch. It can be seen with a little difficulty, but I think plainly, that the rocks at Purgatory dip steeply eastward. The rocks west of the bathing-beach dip easterly again, so that the beach and little bay occupy, apparently, a simple synclinal.

## II. BOTANY AND ZOÖLOGY.

### 1. THE FRUIT-BEARING BELT OF MICHIGAN. By Prof. ALEXANDER WINCHELL, of Ann Arbor, Michigan.

THE hydrographical position of the lower peninsula of Michigan gives rise to climatic conditions which possess a high degree of interest and industrial importance. The full effect of the situation has not been understood till within a recent period; and, so far as its influence upon the industry of the State is concerned, is, to the present time, rather anticipated than experienced. I refer to the equalizing influence of the "great lakes" upon the climate of the State, especially that of the western slope.

Lake Michigan, being a body of water 350 miles long, and, on an average, 75 miles broad, with a depth of about 900 feet, is enabled to preserve something of that uniformity of temperature which characterizes the ocean, and exerts a similar influence upon the contiguous lands. The temperature of the water in the open lake never rises above 45° or 50°, and probably does not sink below 35° or 40°. The great body of the lake is never frozen over. The winds moving over its surface are consequently warmed in cold weather and cooled in warm weather. As the prevailing direction of the wind, both summer and winter, is from the westerly points of the compass, the influence of the lake is most extensively felt along the eastern or Michigan shore. The amount of this influence diminishes toward the interior, but is distinctly felt, in extreme weather, in all parts of the State. The region of country along the lake, however, for a distance inland which may be put at about 40 miles, enjoys a climate of a decidedly local character. The amount of this influence, and its importance upon the agricultural economy of the State, induce me to make this attempt to direct more special attention to the facts.

Exact statistics of the climate have not been preserved along the southern portion of this belt, from St. Joseph to the Grand Traverse region. The contrast in the crops and general vegetation, however, on the opposite shores of the lake, corresponds to a very considerable difference in the extremes of the climates. When the thermometer is

40° below zero at Janesville, Wisconsin, it is 30° below at Chicago, and 20° below at Kalamazoo, 45 miles east of the southern portion of the lake. During the prevalence of the severest cold of last winter, the mercury stood from 15° to 20° lower at Milwaukie than at Grand Haven, immediately opposite.

In the northern portion of the belt under consideration, reliable meteorological statistics have been preserved. This region is known as the "Grand Traverse region," and lies around the bay of that name, — a navigable arm of Lake Michigan, projecting southwards into the interior a distance of 35 miles, and having a mean breadth of about 10 miles. This region has a mean latitude of about 45°, with a mean elevation above the sea of about 800 feet. It lies in nearly the same latitude as Nova Scotia, the middle of Maine, northern Vermont and New York, and St. Paul, Minnesota. Having recently reported at length upon the physical features of this region, I shall refer to that report for details.[1] I propose to cite here only a few general conclusions from the facts in my possession.

I have directed special attention to the winter climate, since this is the season which, in high latitudes, is generally regarded as exerting the most unfavorable influences upon vegetable and animal life. I have taken a series of thermometrical observations, kept at Traverse City, at the head of Grand Traverse Bay, and compared them with observations reported from various other localities east and west, which lie nearly in the same latitude, and with other localities two or three degrees further south. The localities selected as lying nearly in the latitude of Traverse City are Manitowoc, Wis., Hazlewood, Minn., St. Johnsbury, Vt., Gardiner, Me., and Montreal, C. E. As representatives of more southern localities, I have chosen Ann Arbor, Mich., Janesville, Wis., and Dubuque, Iowa.

Of the co-latitudinal localities it will be observed that Manitowoc is located immediately on the western shore of Lake Michigan, and has Green Bay lying not over 35 miles to the north. It necessarily experiences, therefore, some modification of its winter climate from the influence of those large bodies of water. In this respect, it seems even to be more favored than Milwaukie, 75 miles further south, which has colder winters, — the difference, perhaps, being the measure of the influence of Green Bay upon the winter climate of Manitowoc. Hazlewood, Montreal, and St. Johnsbury are situated inland, and may be taken as fairly representing the continental temperature on their parallels, as unmodified by large bodies of water.

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[1] "The Grand Traverse Region." By A. Winchell, 1866.

The comparisons instituted have been of three kinds: (1.) Between the mean temperatures of the wintry months, embracing December, January, February, and March. (2.) Between the *mean minima* of the several wintry months. (3.) Between the *extreme minima* of the several wintry months. The following is an abstract of the results of such comparisons:—

The adaptation of a winter climate to the safe wintering of fruit-trees and farm crops is not indicated by the mean temperature of the winter, nor by the mean temperatures of the several months. Nevertheless, when this comparison is made, we perceive that the climate of "Traverse City" is milder than that of any of the localities brought into comparison with it. In the month of December, Manitowoc is over 1° colder; Hazlewood, 12½°; St. Johnsbury, 8⅓°; Gardiner, 5¼°; Montreal, 7°; Ann Arbor, 1¼°; Janesville, 2¾°; Dubuque, 1°.

In the month of January, Manitowoc is 2¼° colder than Traverse City; Hazlewood, 15⅔° colder; St. Johnsbury, 5°; Gardiner, 5⅓°; Montreal, 10¾°; Ann Arbor, 3°; Janesville, 11⅓°; Dubuque, 2°.

In the month of February, Manitowoc is half a degree warmer than Traverse City; Hazlewood, 10½° colder; St. Johnsbury, 9½°; Gardiner, 4½°; Montreal, 6°; Ann Arbor, 4°; Janesville, 4°; Dubuque, 2°.

In the month of March, the mean of the more southern localities begins to feel the influence of occasional warm southerly and southwesterly winds, while Traverse City is still environed by the winter temperatures, imprisoned in the ice of the bay.

It is the *extremes* of winter temperature which produce such frequent destruction of the more delicate varieties of fruit-trees. On comparing the *mean minima* of the several places for the cold months of the year, we obtain the following results: In December, the *mean minimum* of Manitowoc is 4° lower than at Traverse City; of Hazlewood, 15½° lower; of St. Johnsbury, 23½°; of Gardiner, 13½°; of Montreal, 15°; of Ann Arbor, 1°; of Janesville, 8¾°; of Dubuque, 3¾°.

In January, the *mean minimum* of Manitowoc is 5¼° below that of Traverse City; of Hazlewood, 18½°; of St. Johnsbury, 17½°; of Gardiner, 17¼°; of Montreal, 16¼°; of Ann Arbor, 5½°; of Janesville, 17°; of Dubuque, 3°.

In February, the *mean minimum* of Manitowoc, for the years compared, is 3° higher than at Traverse City; of Hazlewood, 9° lower; of St. Johnsbury, 14¾° lower; of Gardiner, 1° higher; of Montreal, 8½° lower; of Ann Arbor, the same; of Janesville, 12½° lower; of Dubuque, ⅔° lower.

The *mean minimum* of March is lower for every one of the places compared with Traverse City.

The favorable character of the climate of Traverse City is placed in a still stronger light if we compare the *extreme minima* for a series of years. The *mean minimum* may be of moderate severity, while on one or two occasions in the course of the winter, or still more likely, within a range of five or six years, the mercury may sink to the destructive limit. The *extreme minimum* of Manitowoc compared with that of Traverse City is found to be, in the month of December, 10° lower; of Hazlewood, 22°; of St. Johnsbury, 28°; of Gardiner, 19°; of Montreal, 26°; of Ann Arbor, 3°; of Janesville, 14°; of Dubuque, 10°.

In January, the *extreme minimum* of Manitowoc is 8° lower than at Traverse City; of Hazlewood, 18°; of St. Johnsbury, 26°; of Gardiner, 18°; of Montreal, 16°; of Ann Arbor, 10°; of Janesville, 15°; of Dubuque, 6°.

In February, the *extreme minimum* of Manitowoc is 1° lower than of Traverse City; of Hazlewood, 13°; of St. Johnsbury, 16°; of Gardiner, 3°; of Montreal, 22°; of Ann Arbor, 1° higher; of Janesville, 9° lower; of Dubuque, 5° lower.

It thus appears that, under every point of view, the winter climate of Traverse City is materially milder than that of other places in the same latitude, either east or west. It is materially milder than that of places 2½ degrees further south. The *minimum* range of the thermometer being but 15° below zero, it does not reach the point at which peach-trees are injured; and, in this respect, the winter climate compares favorably with that of middle Ohio, Indiana, and Illinois. Indeed, the winter extremes for ten years past, during which peach-trees have been growing in the Grand Traverse region, have been less than at Cincinnati or St. Louis, or even Memphis in Tennessee. During the memorable "cold spell of New-Year's, 1864," the thermometer is reported to have sunk at Milwaukie and Janesville, Wisconsin, to 40° below zero; at Chicago, to 29° below; at Kalamazoo, Michigan, to 20° below; at St. Louis, to 24° below, and at Memphis, Tenn., to 16° below; while at Traverse City, it only reached 14° below, and at Northport, at the mouth of the bay, the same; and ranged as low as zero only on two different days. This cycle of cold weather, which extended over the entire north-west, and destroyed or damaged fruit-trees in every north-western State, caused no damage whatever in the Grand Traverse region.

Other comparisons are no less surprising than those which have just been made. Autumnal frosts are postponed to a remarkably late period. Unlike other regions, frost seldom appears till the mercury reaches 32°. The first killing frosts ordinarily occur throughout the region between the middle and end of October. Sometimes they are delayed till late in November. The first damaging frost occurred, last fall, on the night of the 28th of October. On the 5th of November it froze again. At the same time the mercury sunk to 24° at Ann Arbor, and to zero at Bangor, in Maine. I saw the forests of the Grand Traverse region still green, while those of the southern portion of the State were browned, or completely defoliated.

Snow falls in November or December before the ground has been materially frozen, and lies, without thawing, until the following April. The soil consequently escapes freezing throughout the entire winter, so that root crops may be left out without damage. Potatoes are thus frequently wintered without digging, and those ordinarily left in the ground propagate themselves from year to year, and become naturalized. In the same manner, the tubers of dahlias remain in the earth with impunity, and delicate green-house roses stand out with greater security than in Alabama and Louisiana.

The snow disappears about the 10th of April, and the ice in the bay breaks up about the same time. By this time the season is so far advanced that the influence of the water is capable of resisting any subsequent tendency to severe frost. No frost, detrimental to farm crops, is liable to occur later than the middle of May.

The facts which I have thus disclosed touching the winter climate of the Grand Traverse region, are well calculated to excite surprise.

The equalizing influence of the lake is much greater than is generally supposed; and the whole belt of country bordering it on the east is affected by its hydrographical position, much like the peninsula of Florida, Sweden, and the British Islands. In the Grand Traverse region the body of water is greatly augmented by the bay, which reaches its two arms thirty-four miles into the interior. Moreover, the triangle formed by Leelanau county is embraced by two large bodies of water, and enjoys a situation unlike that of any other portion of the north-western States.

There is one circumstance which affords the Grand Traverse region a greater amount of protection than is experienced by the St. Joseph region. The most destructive winds in that part of the country proceed from the south-west; and the peculiar curvature of the lake is such, that south-west winds, striking the Grand Traverse region, must have traversed nearly the whole length of the lake; which is not the case with points further south.

Moreover, it will be observed that the Grand Traverse region is measurably protected from cold easterly winds. By the narrowing of the Michigan peninsula, in that part of the State, the influence of Lake Huron is felt during easterly storms; and the triangle of Leelanau county experiences, also, the special protection of the bay. As, in this part of the country, the thermometer occasionally sinks very low with a strong easterly wind, protection from this quarter becomes a most important consideration.

A region defended, like that along the eastern shore of Lake Michigan, from the extreme vicissitudes of our northern winters, and preserved equally from the torrid heats and protracted drouths of our southern summers, would seem to be favorably situated for drawing forth the utmost capabilities of the soil. As it is obvious that a favorable soil is an essential condition to the full effect of so propitious a climate, I ought to add that on the immediate shore of the lake the soil is generally sandy, and covered by a forest growth consisting of evergreen and deciduous trees intermixed. From half a mile to three miles inland, the soil becomes more loamy; and in Newaygo, Oceana, and Mason counties, receives an ample supply of calcareous material from the mountain limestone which underlies. In the Grand Traverse region the soil is a calcareous sandy loam, derived from the disintegration of the arenaceous limestones and shales of the Hamilton group which outcrop in Little Traverse Bay, and dip southward under the Grand Traverse region. This soil is of an admirable quality for general agricultural purposes. It is covered by a very heavy growth of sugar-maple, beech, rock-elm, and white-ash, with magnificent hemlocks locally interspersed. As a general rule, there is no pine and no swamp land. The whole region is elevated and rolling.

The entire belt, from the head of Lake Michigan to Little Traverse Bay and perhaps beyond, is well adapted to the production of the more delicate varieties of fruits. Peaches and sweet cherries (*Cerasus avium*) are uniformly successful throughout the whole extent of the region; though it is probable that the progress of the clearing of the forests will create, as in the older portions of this State, a greater liability to extremes, especially in the southern and eastern borders of the belt. For the present, these fruits are successfully cultivated as far east as Kalamazoo and Grand Rapids. In the interior and eastern portions of the State, they are a failure four years out of five. "The St. Joseph region," as it is styled, has for some years been acquiring celebrity as a peach-producing country. The crops that have been raised are almost incredible, though I am not prepared to furnish definite statistics. More recently it has been demonstrated that the peach flourishes equally well as far north as Grand Rapids and Grand Haven; and large investments are being made in this culture. From the statistics of the "Lake Shore Horticultural Association," I learn that there are already under cultivation, in the immediate vicinity of Grand Haven, 7,603 apple-trees; 1,286 pear-trees; 26,580 peach-trees, of which 12,664 were set last spring. Of plum, nectarine, apricot, and quince trees, there are 756. There are 18,693 grape-vines, of which 1,700 are bearing, and 14,993 newly set. These trees, and many others which I have recently examined, are in a state of health and vigor which cannot be surpassed. At Muskegon, and in that vicinity, I observed that peach and cherry trees were laden with fruit in the middle of July of this year; though both crops are a complete failure through the eastern part of the State, and as far south as Tennessee, according to my own observation. Still further north, in the Grand Traverse region, it seems to be completely demonstrated that these fruits are destined to be as successfully cultivated as in the St. Joseph region. As a fruit-growing region, I doubt whether any other portion of the United States, east of the Rocky Mountains, will be able to compete with it. It has been a complete surprise to the inhabitants to learn peaches, apples, grapes, pears, raspberries, strawberries, and other fruits, can be cultivated with success. The discovery has given a wonderful impetus to this branch of enterprise; and, unless my judgment greatly misleads me, we shall hear of the Grand Traverse region, within ten years, as the fruit-orchard of the country; and shrewd men, with horticultural tastes and a moderate amount of means, will thank me for directing attention to this open avenue to wealth.

P. S. — Since the foregoing paper was read, I have been informed by Dr. I. A. Lapham, of Milwaukie, that the themometer sank at that place only to —30° on the first of January, 1864. I have also received his chart of the summer and winter isothermal lines which cross Lake Michigan, showing that the lake affects the climate very perceptibly, even in the region lying to the westward. In comparing the meteorological *means* of Traverse City, therefore, with localities in Wisconsin and Minnesota, the contrasts, though well marked, are not so salient as if the comparisons had been made with localities quite removed from the interference of the great lakes. The windward position of Wisconsin, however, during our coldest storms, would prevent the *extreme minima* of the climate from receiving any alleviation from the proximity of the lake.

## 2. STROMATOPORIDÆ: THEIR STRUCTURE AND ZOÖLOGICAL AFFINITIES. By Prof. ALEXANDER WINCHELL, of Ann Arbor, Michigan.

A RECENT investigation of the organic remains of Little Traverse Bay, in the State of Michigan, has caused my attention to be directed to the nature and zoölogical relations of the Goldfussian genus *Stromatopora.* Without attempting to present a synopsis of the literature of the subject, or even to enter upon a full discussion of the organic nature of the beings embraced under the genus, I desire to present a few suggestions, based on some interesting facts that have come under my observation.

The genus *Stromatopora* was first briefly characterized by Goldfuss about the year 1827 (Petrefacta Germainæ, I., p. 21), in the following words: —

"*Polyparium hemisphæricum s. subglobosum, e stratis solidis et fungoso-porosis alternantibus contiguis.*"

The first species described was *S. concentrica* from the Devonani limestone of the Eifel: "*S. stratis concentricis infundibuliformis undatis.*"

Save that the author seems to have contemplated the object in an inverted position, and thus to have figured it, the description of this species will apply to a large proportion of the massive *Stromatoporæ* that have been since observed. Accordingly we find that authors have been in the habit of referring to this species a wide range of distinguishable forms from various different formations.

In his remarks upon this species, Goldfuss says, it sometimes attains a diameter of several feet. The funnel-form layers fit into each other in such manner that the inner and upper gradually become smaller and flatter. The outer are generally undulated. All together form, with their outcropping edges, the even, concentrically furrowed upper surface of the coral-body. With a magnifier one is able to discover that the basis of the thicker beds is a complicated net-work, while the spongy intervening beds are composed of coarse interwoven fibres.

At a later period (Petr. Germ. I., p. 215), the learned author presented the results of his investigation of the various forms which he brought together under the name of *Stromatopora polymorpha*. He remarks that while the study of the former species had led him to associate it with true corals, giving it a position between millepores and madrepores, his later studies led him to range *Stromatopora* under the sponges. *S. polymorpha* was described as being primarily a thin incrustation of spongy matter deposited upon a coral, shell, or other submarine body, preserving on its exterior all the inequalities of the supporting body. Upon this successive layers of similar matter were deposited, until the organism assumed its destined form, and the primitive body dissolved away, leaving a cavity in its place. Partly through the inequalities of the primitive body, and partly through the unequal deposition of the successive spongy layers, the surface became tuberculated, warty, or even cylindrically or ramosely elevated. Through weathering and attrition, the summits of these eminences became worn down through one or more of the layers, so as to exhibit concentric rings. The summits and their vicinity acquire chinks or fissures, as the learned author expresses it, which penetrate the first beds of the net-work, and thus form vermicularly diverging furrows. The apex of the tubercle is frequently perforated by a hole, which, in some instances, is considerably enlarged and surrounded by one or more series of smaller holes.

This organism, in its various states of growth and weathering, presents the varied forms which the author had previously described as *Tragos capitatum*, and *Ceriopora verrucosa*, — in some instances, also, bringing out the characters of *Mermecium* and *Siphonia*, — facts which lead him to conclude with the just reflection that in the classification of organic bodies we must be guided by the essential organic structure; for mere surface physiognomy is capable, as in this case, of leading to the admission of several genera within the limits of even a single species.

In 1839 Lonsdale, besides characterizing a new species (*S. nummulitisimilis*), having a flattened, discoidal form, from the Wenlock limestone, identified *S. concentrica*, from the Wenlock limestone and shale (Silurian System, pp. 680–1, pl. xv., figs. 31 and 32). The latter was properly made a new species by D'Orbigny in 1847, under the name of *S. striatella*, in consequence of the much greater compression of its layers (Prodrome de Pal. I., p. 51); and this change was adopted by McCoy in 1851 and by Murchison in 1859 (Siluria, p. 210). It is a massive coral, like *S. concentrica*, and is generally represented as growing around some submarine organic body.

In 1847 Prof. Hall characterized the genus *Stromatocerium* to receive an obscure species from the Black River limestone, which he named *S. rugosum* (Pal. N. Y., I. p. 48, pl. xii., fig. 2). Judging from the description and figures, this fossil is completely congeneric with *Stromatopora concentrica*, and has been so regarded by D'Orbigny, Pictet, Billings, and others.

In the same year, D'Orbigny separated the tuberculated and mammillated forms of *S. polymorpha* as constituted by Goldfuss, and established for their reception the new genus *Sparsispongia* with the species *S. polymorpha*, *radiosa*, and *ramosa* (Prod. de Pal. I., p. 109).

Pictet has admitted this genus and made it the type of a tribe of sponges (Paleont. IV., p. 548), while McCoy indentifies it with *Caunopora* of Phillips.

In 1851 Prof. McCoy investigated *Stromatoporæ*, and controverted, the general impression that they are sponges, since the whole mass, being composed of rigid, though vesicular, curved plates, would be incapable of those systolic and diastolic motions essential to the life of a sponge. On the other hand, he detected in the intercellular structure of *Palæopora*, *Fistulipora*, etc., something analogous to the vesicular structure of *Stromatopora*, and thought he discovered, also, some faint indications of the existence of individual polyp cells. He accounted for the absence of cell-walls by the supposed exserted position of the polyp, as in *Goniopora*. He accordingly places *Stromatopora* in the *Tubiporidæ*, near *Fistulipora* (Brit. Pal. Foss., p. 12). He regards *Caunopora* as a sub-genus of *Stromatopora*.

In 1862 Mr. Billings described a second species — *S. compacta* — from the Black River limestone (Paleozoic Foss., p. 55), which differs from *S. rugosa* as *S. striatella* does from *S. concentrica*. Mr. Billings first ranged these organisms under Amorphozoa, but from later examinations he states that he was led to regard them as corals allied to *Fistulipora* (Ib., p. 213).

It may be further stated that Geinitz places a portion of the *Stromatoporæ* under Madrepora (Versteinerungs-kunde, p. 580), and others under Nullipora (Ib., p. 583); Agassiz places them under Milleporina (Nomenclator Zoöl.); Bronn, under Bryozoa (Index, Pal. II., p. 1203); Pictet, under Spongiaires (Paleont. iv., p. 556); while Dana, in one instance, ranges *Stromatopora* under Bryozoa (Man. Geol., p. 191), and in another, under Radiates (Ib., p. 240).

I now proceed to give the results of my own observations upon the four species discovered in the Hamilton group of Michigan and Ohio, and recently described in my report on the " Grand Traverse Region," pp. 90–1.

*Stromatopora pustulifera* is a species which occurs in large, spheroidal, ovoid, or elongate masses, composed of arching, transverse, concentric layers formed of laminæ of coralline substance, separated by a net-work of minute passages, which, at intervals, coalesce and turn upwards through the bed, radiating and ramifying again on its upper side. The places where the beds are thus traversed are raised, on the upper side, into little eminences. The distinction into beds is produced by variations in the density of the coralline substance. Masses of coral occur, several feet in length, and even in diameter. The distance of the pustules 4 millimetres, or .16 inch; and the mean thickness of the laminæ one-fifth of a millimetre, or .008 inch.

*Stromatopora monticulifera* has a structure and form like the preceding, but differs therefrom in the much larger and more remote eminences on the upper surfaces of the concentric beds, and in the larger and more distinctly radiating character of the passages which diverge from the apices of the monticules. These passages, on the exposed surface, are little, flexuous, somewhat branching furrows, which diminish in size and disappear within 5 millimetres or .2 inch. The distance of the monticules is from 7 to 10 millimetres. This coral attains a diameter of at least 3½ metres or 12 feet. I have found it in Little Traverse Bay, on the west side of the State; on Thunder Bay Island, on the east side; and on Kelly's Island, near Sandusky, Ohio.

The two species thus described evidently possess some affinity with the verrucose forms embraced by Goldfuss under *S. polymorpha*, and separated by D'Orbigny under his genus *Sparsispongia*. The distinct, vermicular perforations suggest, also, an affinity with *Caunopora*, Phillips. The great regularity and persistence of the eminences, however, render it impossible to account for them, as Goldfuss did, by an unequal deposition of coralline substance, or by original inequalities in the primitive body upon which the corallum was formed. Indeed, though I have seen ship-loads of these corals, I have never detected evidence that they were in any sense incrusting. The concentric layers are only segments of circles passing transversely across the spheroidal, or more often elongated mass, — many of which I have seen standing erect in the face of an escarpment, with the ruins of other beings and other generations strewn around them. The *débris* of these organisms have formed literal coral reefs, and constitute, in Little Traverse Bay, almost the entire mass of a bed of buffish limestone twenty-five feet in thickness.

Neither can I agree with Goldfuss, that the radiating furrows and perforations are caused by attrition or disintegration of the apica portions of the eminences. They are always most distinct on the freshly exposed surfaces, and show as well on the under side as the upper side of the layers.

The third species which I have described is *Stromatopora nux.* This occurs in moderate-sized spheroidal, sometimes contiguous and coalesced masses, formed, unlike the foregoing species, by accretions on all sides, and is often seen to be parasitic. The external surfaces of the layers are not pustulose. Masses occur from 2½ to 12 centimetres, or 1 to 5 inches, in diameter. This species has also been recognized on Kelly's Island.

This is one of the species commonly referred, in this country, to *S. concentrica*, Goldf.; but I do not believe that species exists in America. *S. nux* differs from *S. concentrica* in the same manner that *S. striatella* does; but the latter is an Upper Silurian and a European species, and I should hesitate to unite it with *S. nux.*

Lastly, a most unexpected and remarkable form has come under my observation, which I have described as *S. cæspitosa.* In general *ensemble* it looks like a large, cespitosely branching Cyathophylloid coral. The stems are externally in contact, or 15 to 25 millimetres apart. A longitudinal section shows the characteristic layers arching across the stem and resembling *S. pustulifera* in miniature. A transverse section exhibits a radiating structure, as in *Cyathophyllidæ ;* but there is no outer wall or definite limitation to the structure, and the interior is completely filled with concentric circles of coralline substance, except a small perforation in the centre. The exterior is longitudinally vermicular-striate. Diameter of stem 4½ to 7½ millimetres, or .18 to .30 inch. It occurs in masses from 6 to 9 decimetres, or 3 to 4 feet in diameter.

I think there can be no doubt that this species conforms to *Stromatopora*, as defined by Goldfuss and McCoy. It possesses the concentric and reticulated layers of *S. concentrica, pustulifera,* and *monticulifera.* It is not enveloping, like the former, but presents an exaggerated condition of the unwalled pile of layers characterizing the two latter species. On the contrary, the *ensemble* is that of a Cyathophylloid, and traces of radial, lamellar lines are actually present, producing irregular longitudinal striæ on the exterior. It seems to possess, therefore, undoubted affinities with those genera of *Cyathophyllidæ* in which the mural system is feebly developed, and the diaphragms and lamellæ tolerably well represented. In short, it seems to exhibit a transition from *Stromatopora* proper to *Cyathophyllidæ.*

The affinities of this species with *S. pustulifera* and *monticulifera* carry the two latter also into the group of Zoantharia. These two species, moreover, in their regularly distributed eminences, with their apical perforations and vermicularly radiating channels, preserving a vertical relationship of structure, in straight lines, through hundreds of the concentric layers, show that their upper surfaces have been locally and regularly differentiated through individualized portions of the sarcoid mass. In other words, each eminence answers to a polyp-cell. The radiating channels have some reference to a septal system, which in *S. cæspitosa* comes into still more visible existence. The diaphragms become confluent in contiguous polyp-cells, as in *Dania* and some other genera, and as becomes the case with the lamellæ of *Smithia* and *Phillipsastræa.* In *S. concentrica* we have a more degraded condition of the same fundamental structure. The specialization of the surface is visibly wanting; the septal system is only obscurely shadowed forth by the reticulated passages between the spongy layers; the common polyp mass becomes little more than a simple sarcode, resting on the upper surface and filling the subjacent interstices; and, finally, its low organization is further signalized by its parasitic habit and its tendency to flow around and attach itself to all sides of its support.

It must be admitted that such forms as have been referred to *Sparsispongia* possess characters in common with other genera, commonly included among sponges, such as *Chenendopora*, Lamouroux, and *Forospongia* and *Verrucospongia*, D'Orbigny; and the radiating furrows may even be compared with those of such solitary forms as *Cnemidium rotula* and *mammillare*, Goldf. (Petr. Germ. Tab. VI., figs. 5 and 6), and *Siphonia præmorsa*, Goldf., as figured by Hisinger (Petrif. Svec. Tab. XXVI., fig. 7); but these affinities, instead of drawing our *Stromatoporæ* toward Amorphozoa, only raise the question whether the affiliated genera are not also sufficiently related to polypi to fall under a particular family of Zoantharia.

For reasons set forth above, I should agree with Agassiz and McCoy in placing the *Stromatoporæ* amongst Zoantharia, but I should differ with both in deciding upon their local affinities. Agassiz seems to have placed them in Milleporidæ, governed by the minutely vesicular structure of the mass; homologizing this with the cellular structure of the cœnenchyma of Millepores; while, in my own view, these corals are destitute of cœnenchyma, and their vesicular tissue is endo-structural, and ought to be homologized with that of *Cystiphyllum*, or perhaps more properly with the vesicular zone of *Cyathophyllum* and *Heliophyllum*. McCoy has also viewed this vesicular tissue as intercellular, in ranging *Stromatopora* by the side of *Fistulipora*. But it differs from *Fistulipora* and *Palæopora* as well as the *Milleporidæ* in general, in the absence of the mural system and the confluence of the diaphragms of contiguous individuals.

It is true that the great predominance of the septal system is capable of suggesting very strongly a subordination to the type of Zoantharia tabulata; but the want of a mural system shows a divergence equally great, and a corresponding affinity with the Aporosa, and exceptional cases of the Rugosa with which I associate them; while the general affinities of the species which I have discussed throw a great weight of evidence in support of their Cyathophylloid relationship.

It is evident that the different species of *Stromatopora* which have been brought under discussion present three distinguishable plans of detailed structure: —

1. We have the cæspitose, completely individualized form, retaining traces of lamellæ. This is evidently most nearly related to *Cyathophyllidæ;* and I am not aware that it has been noticed by any author.

2. The forms with the confluent but not obliterated individualities, preserving the diaphragms, but losing the lamellæ, represented by *S. polymorpha*, Goldf., *Sparsispongia*, D'Orb. The name proposed by D'Orbigny could be retained for this type, if it were not a clear misnomer.

3. The forms with confluent and obliterated individualities. These embrace the original type of the genus *Stromatopora*.

The forms described under the name *Caunopora*, Phillips (Pal. Foss. t. x.; fig. 29, etc.), notwithstanding McCoy's suggestion, seem to be sufficiently distinct from *Sparsispongia*, and should probably constitute a fourth generic type holding position next above *Stromatopora* proper.

If the views presented above prove to be tenable, we shall have the following arrangement and diagnoses of *Stromatoporidæ:* —

*Family Stromatoporidæ.* — Polyps isolated or confluent; exserted, never forming a cup; secreting a coralium which consists of a series of concentric layers (or diaphragms) of vesicular tissue, separated and perforated by vermicular, ramifying passages, which are either radially or confusedly disposed. Mural system wanting; lamellar structure distinctly present only in the higher forms.

Genus, *Idiostroma*, (n. g.) — Polypi completely isolated, forming branching masses; lamellar system, represented by a radial structure.

Species, *I. caespitosum, gordiaceum.*[1]

Genus, *Cænostroma*, (n. g.) — Polypi confluent, but individualized, forming elongated, or spheroidal, compound masses; diaphragms common and continuous throughout; lamellar system indicated by the radiate arrangement of the vermicular passages which commonly diverge from the summits of little eminences raised in the concentric laminæ.

Species, *C. pustulosum, monticuliferum, granuliferum,*[2] *polymorphum, radiosum, ramosum.*

Genus, *Caunopora*[3] (Phillips). — "Corallum polymorphous, composed of minute, irregular, vermicular, cellulose tissue, disposed in obscure concentric layers, traversed by few long, larger, variously disposed, vermiform, cylindrical channels." (McCoy, Brit. Pal. Foss, p. 66.)

Species, *C. placenta, ramosa, verticillata.*

Genus, *Stromatopora* (Goldf.)—Polypi confluent, with individualities sensibly obliterated. Corallum consisting essentially of confluent diaphragms, or concentric layers, which generally inclose a foreign body, —being secreted on all sides of it and forming a spheroidal mass.

Species, *S. concentrica, striatella, nux, rugosa, compacta, nummulitisimilis.*

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[1] *Idiostroma gordiaceum* (n. sp.) — In general appearance resembles *I. cæspitosum.* The stems, however, are intricately entangled, and radial lamellæ have a distinct existence; thus showing a still nearer approach to the Cyathophylloids. A very interesting species from Iowa City, Iowa.

[2] This species occcurs at Charleston Landing, Indiana, a few miles above Jeffersonville. It differs from *C. pustulifera* in having the upper surface of the layers more minutely pustuliferous or granulated.

[3] It is yet desirable to compare authentic specimens of this type with specimens of *Idiostroma*; though, if, as McCoy asserts, its affinities are with *Sparsispongia* (from which I think it differs materially), it is a very different type from *Idiostroma.*

# C. PRACTICAL SCIENCE.

## 1. On the Link of Gunter's Chain as the Unit of a Decimal System of Weights and Measures. By B. S. Lyman, of Philadelphia, Penn.

The object of this paper is to call attention to the fact of our having already in use a decimal system of measures, and to the feasibility of its general extension.

In replacing our ordinary measures and weights by new decimal ones, it is less important to have the same unit with other countries than to have easy means of converting the old measures into the new; for conversion from one decimal system to another is comparatively easy, and it is chiefly importers and travellers and readers of foreign books alone who need to compare foreign measures with ours. Of all measures land measures will need for the longest time to be frequently converted from the old standard to the new, on account of the great length of time that a land deed remains in use; and they also require most time for us to learn to conceive of them accurately.

If the link of Gunter's Chain, a measure widely used by land surveyors, and familiar, also, to most land owners, were taken for the standard unit of a decimal system, the important denominations of link, chain, furlong, and acre would remain absolutely unchanged. The link is 7.92 inches, and is within a twentieth of an inch of one-fifth of the French metre. Ten links are six feet and 7.2 inches, and might be called a fathom, since there are so many fathoms in use as to make it hitherto a rather indefinite length; and this fathom would be almost exactly equal to two metres, or to the Saxon Lachter. The mile might be lengthened so as to be ten furlongs (nearer than our present mile to the geographical mile), and then a square mile would contain 1000 acres. Since the link is about eight inches, or two hands, one tenth of it might be called a finger, and it would be almost exactly the length of the (theoretical) diameter of the new five cent. coin. One hundredth of a link is $\frac{8}{100}$, or $\frac{19}{20}$ of the present line, and might be called a line.

A cubic link contains 497 cubic inches, between two wine gallons and two dry gallons of our present measures, and might be called a peck; and that name might be applied, like gallon, equally to liquids and to dry bodies. The peck would be the unit of measures of capacity and of bulk.

A cubic link of water at its greatest density weighs eighteen pounds, and might be called a stone, and serve as a unit of weight.

As for the names of a new system of weights and measures, they ought to be at least idiomatic, and not, like the French metrical names, a mass of pedantic barbarisms, which would appear still worse if foisted wholesale into our language than they do in French, and would be still less intelligible to the unlearned. The old names might be retained for those new weights and measures that are nearly equal to old ones, or that occupy the same general position in the system even when they are quite unequal; and they might be distinguished by the prefix "new" until the system came into general use. Those weights and measures that are quite new might easily find new names analogous to the old ones, taken from familiar objects or from some provincial measures or weights.

We should have, then, the following tables of weights and measures: —

1 Link = $\frac{1}{10}$ Fathom = $\frac{1}{100}$ Chain = $\frac{1}{1000}$ Furlong = $\frac{1}{10000}$ Mile.
= 10 Fingers = 100 Lines.
1 Square Link = $\frac{1}{100}$ Square Fathom = $\frac{1}{10000}$ Square Chain = $\frac{1}{100000}$ Acre.
1 Acre = $\frac{1}{10}$ Square Furlong = $\frac{1}{1000}$ Square Mile.
1 Peck (cubic link) = $\frac{1}{10}$ Cask = $\frac{1}{100}$ (Tun ?).
= 10 Quarts = 100 Gills = 1000 (Thimbles ?).
= $\frac{1}{100}$ Perch = $\frac{1}{1000}$ Cord.
1 Stone (cubic link of water) = $\frac{1}{10}$ Quintal = $\frac{1}{100}$ Ton.
= 10 Pounds = 100 (Pebbles ?) = 1000 Drams
= 100,000 Grains.

The new grain would weigh 1.26 old grains; and eight of the new five cent coins would (theoretically) weigh 500 new grains.

It would perhaps give no serious additional trouble to alter the link to the exact fifth of a metre, particularly if the French would alter their metre to its intended original standard.

# TITLES

# OF

# COMMUNICATIONS.*

## A. MATHEMATICS, PHYSICS, AND CHEMISTRY.

1. Calculating Machines in Europe. By E. B. Elliott.
2. New and Compendious Method for the Construction of Life-Tables from Returns of Population and Mortality. By E. B. Elliott.
3. Remarks upon Fundamental Star-Catalogues. By T. H. Safford.
4. On the Geographical Position of Alfred Observatory. By W. A. Rogers.
5. Some Account of an Investigation of the Path of a Meteoric Fire-Ball, which passed over some of the Northern Parts of the United States and over Canada, on the Evening of July 20, 1860. By James H. Coffin.
6. General Meteorological Features of the West. By O. N. Stoddard.
7. Remarks on the New Method of Automatic Registration of Meteorological Phenomena. By G. W. Hough.
8. The Aelloscope. By H. A. Clum.

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* The following papers were also read, but no copy of them has been furnished for publication.

9. On the Primary Triangulation of the Coast of New England, in Connection with the United States Coast Survey. By J. E. Hilgard.

10. On a Map of the Magnetic Declination in the United States, prepared at the U. S. Coast Survey Office. By J. E. Hilgard.

11. On Methods of Illumination of Opaque Objects, under High Powers of the Microscope; with a Description of a New Illuminating Apparatus. By F. A. P. Barnard.

12. Insufficient Strength of Steam Boilers. By O. N. Stoddard.

13. Causes of Steam-boiler Explosions. By James Hyatt.

14. On the Law of the Mutual Action of Elements of Electric Currents. By E. B. Elliott.

15. The Effect of Sunshine on Fires. By E. N. Horsford.

16. On a new Chemical Nomenclature. By S. D. Tillman.

17. Alum in Bread. By E. N. Horsford.

18. Progress made in the Utilization of Sodium in Gold and Silver Amalgamation. By Henry Wurtz.

19. Why Wood-Spirit may be burned instead of Alcohol to produce Heat. By James Hyatt.

## B. NATURAL HISTORY.

20. Mineralogy: its Objects and Method. By T. S. Hunt.

21. Preliminary Note and New Theory of the Genesis of Auriferous Sulphids and of Fluviatile and Lacustrine Gold. By Henry Wurtz.

22. REMARKS ON THE GEOLOGICAL STRUCTURE OF THE STATE OF ILLINOIS, EXPLANATORY OF THE VERTICAL SECTION OF THE STRATA. By A. H. WORTHEN.

23. ON THE STRUCTURE OF THE MOUNTAINS AND VALLEYS IN TENNESSEE, NORTHERN GEORGIA, AND ALABAMA. By JAMES HALL.

24. SECTION OF STRATA THROUGH SOUTH-EASTERN OHIO, AND THE WESTERN PART OF WEST VIRGINIA. By E. B. ANDREWS.

25. ON THE TERTIARY FORMATIONS OF MISSISSIPPI AND ALABAMA. By E. W. HILGARD.

26. REMARKS ON THE GEOLOGICAL STRUCTURE OF SOUTHERN MINNESOTA. By JAMES HALL.

27. DISTRIBUTION OF BITUMEN IN PALÆOZOIC ROCKS. By E. B. ANDREWS.

28. ON THE ORIGIN OF PRAIRIES. By J. S. NEWBERRY.

29. ON THE GLACIAL EPOCH IN THE VALLEY OF THE MISSISSIPPI. By J. S. NEWBERRY.

30. EVIDENCES OF GLACIAL ACTION IN SOUTH-EASTERN NEW YORK. By JAMES HYATT.

31. REMARKS ON THE DRIFT OF THE WESTERN AND SOUTHERN STATES, AND ITS RELATIONS TO THE GLACIER AND ICEBERG THEORIES. By E. W. HILGARD.

32. GEOGRAPHICAL DISTRIBUTION AND FLOWERING OF PLANTS IN SOUTH-EASTERN NEW YORK. By JAMES HYATT.

33. ON A COMPLETE REGULAR DIMEROUS ORCHID FLOWER. By JOHN A. PAINE, JR.

34. OBSERVATIONS ON THE STRUCTURE AND MODE OF GROWTH OF THE SPINES ON THE CARDINAL AREA OF CHONETES, WITH REMARKS ON THE DISTRIBUTION OF SOME SPECIES OF THE GENUS. By JAMES HALL.

35. ON THE STRUCTURE OF THE SPINES IN THE GENERA ATHYRIS, MORESTELLA, AND OTHER GENERA OF SPIRIFERIDÆ. By JAMES HALL.

36. ON SOME CHARACTERS OF SPIRIFERA AND THE GEOGRAPHICAL AND GEOLOGICAL DISTRIBUTION OF SOME OF THE SPECIES. By JAMES HALL.

37. ON THE PUEBLO INDIANS OF NEW MEXICO. By J. S. NEWBERRY.

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## C. PRACTICAL SCIENCE.

38. ON THE MILITARY CHARACTER AND WEAPONS OF THE RACE OF THE MOUNDS. By CHARLES WHITTLESEY.

39. THE ARMY RATION. By E. N. HORSFORD.

40. RELATIVE TO SICKNESS AND MORTALITY IN THE DANISH AND THE ALLIED ARMIES IN THE SCHLESWIG-HOLSTEIN WAR OF 1863–4. By E. B. ELLIOTT.

41. ON THE DIMENSIONS OF THE HUMAN BODY, AS RELATED TO THE SUPPLY OF LIME AND FIBRIN. By L. C. LOOMIS.

42. ON THE RELATIVE DIMENSIONS OF THE HUMAN BODY. By B. A. GOULD.

43. ON THE VITAL CAPACITY OF THE HUMAN LUNGS AS RELATED TO THE STATURE, THE LENGTH OF THE BODY, AND THE CIRCUMFERENCE OF THE CHEST. By B. A. GOULD.

44. ON THE STATISTICAL SYSTEMS OF CERTAIN COUNTRIES OF EUROPE. By E. B. ELLIOTT.

45. ON A UNIFORM NATIONAL TIME. By L. C. LOOMIS.

46. ON POLITICAL ECONOMY AS A SCIENCE. By CLINTON ROOSEVELT.

47. ON THE SCIENTIFIC AND RELIGIOUS CHARACTER OF EDWARD HITCHCOCK. By ALMIRA LINCOLN PHELPS.

# EXECUTIVE PROCEEDINGS

OF THE

# BUFFALO MEETING, 1866.

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## HISTORY OF THE MEETING.

The meeting which the Association had intended to hold at Nashville, Tenn., in April, 1861, having been prevented by the late rebellion, and a prolonged interruption of several years having occurred in the meetings for the same reason, the Standing Committee took the responsibility, at the earliest opportunity after the return of peace, to renew these annual gatherings of the scientific men of the country, and by a process as nearly conformed to the requisition of the Constitution of the Association as the circumstances of the case permitted.

The Fifteenth Meeting of the American Association for the Advancement of Science was held at Buffalo, N. Y., commencing on Wednesday, August 15, and continuing to Monday evening, August 20.

The number of names registered in the book of members in attendance on this meeting is seventy-nine. One hundred and twelve new members were chosen, of whom all but thirty-five have already accepted membership by paying the annual assessment, and, when practicable, signing the constitution. Sixty-seven papers were presented, most of which were read, and some of them discussed at great length.

The sessions of the Association were held in St. James Hall and in adjacent rooms in the block of the Young Men's Association, of Buffalo. At half-past ten o'clock, A. M., on Wednesday, the members present were called to order by Isaac Lea, LL.D., of Philadelphia, President of the Association during its last convention, who spoke as follows: —

In opening this meeting, it may be my duty to say that when we adjourned last, in Newport, R. I., in 1860, it was then proposed that we should meet in 1861, at Nashville, Tenn. At the same time the distinguished President of Columbia College, N. Y., Prof. Barnard, was appointed to preside at that meeting. In the mean time, the great rebellion breaking out, the meeting was not, of course, called together, as that place was not either a fit or a safe one for loyal members to visit. It was also judged proper that our meetings should be in abeyance, as our minds and our time were occupied by duties of the utmost importance in the assistance of the restoration of that peace which has caused our beloved Union four eventful years of war.

At the return of peace, some of us naturally desired the resumption of the meetings of the Association, and the officers having received an invitation from the liberal and public-spirited citizens of the prosperous and hospitable city of Buffalo, as we had from some other cities, it was decided that the claims of the former to our presence should be accepted. Having said this much in explanation of the lapse of our meetings, I may express my hope and belief in the continued prosperity of our Association. It is now my pleasant duty to introduce to you .President Barnard, and I retire from this chair, which you have honored me with, thanking you most sincerely.

The new President, on taking the chair, said: "Before entering upon the business for which we have assembled, it seems to be fitting that we invoke Divine blessing upon our proceedings, and I invite you, therefore, to unite in prayer with the Rev. Dr. Chester, of Buffalo."

Dr. Chester then offered up a short prayer, at the conclusion of which the Hon. George W. Clinton, President of the Buffalo Society of Natural Science, welcomed the Association, in behalf of the people of Buffalo, in the following words: —

MR. PRESIDENT AND GENTLEMEN OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE, — I regret that I am compelled to speak, in behalf of Buffalo, on this occasion. That duty ought to have been performed by one whose well-earned honors and high position would have given weight unto words of congratulation and of welcome. I can only tell you, what our people are so anxious to prove by their acts, that they do most cordially welcome you to our young city; that Buffalo esteems your presence here a substantial benefit and honor, and that whatever she has or can do, which will minister to the accommodation of the Association, or promote your comfort, or add to your enjoyment, is freely yours. I have no power to give due expression to the profound respect which our people entertain for this Association, and for its grand objects. Its members, in every department of science, have advanced knowledge, and it has won just renown and reflected honor upon our country. National in its organization, the Association slumbered while our national unity was endangered by rebellion; but, with returning peace, it thus gloriously awakes. It does present, to every liberal and patriotic soul, a sublime, an exhilarating spectacle. May this blessed reunion of our men of science prove to be a mere example and a sure harbinger of the heart-reunion of the people of the United States of America for which our souls so yearn! May your Association — in itself so strong an element of unity — grow with the reviving fortunes of our country! God grant that our dear country may present to the world, throughout all time, that most magnificent of earthly spectacles, — a free and peaceful people, warded and exalted by science, and sublimed by true religion.

We congratulate you upon this auspicious resumption of your sessions. And yet, alas! how difficult it is for mortals to find occasion for unmixed joy! Even your present pleasure must be tempered by some thought of the late bitter years; and the delight of renewed intercourse with old associates is mingled with sorrow. Death and disease have not been inactive. Some of those who shed light and pleasure on your meetings are not here. Their presence will never gladden your hearts again. They can do no more for science and mankind. They have gone, or are quickly going, to their reward, and we must soon follow them. Of one, at least, of these public benefactors I can hardly refrain from speaking; but he is not yet dead, —

Heaven grant that he may recover! — and I am not competent to do justice to his great character and achievements. But you must let me say that he was a bright examplar of that magnanimous and catholic spirit which has reigned in this Association from the beginning, and made it so useful and so famous. In recalling his character and acts, I cannot but think of this Association; and you must acquit me of presumption, if I so far yield to the impulses of my heart as to indicate, in my plain way, a few of the reasons why I respect your venerable body.

Your Association has been remarkably free from those bickerings and jealousies which are so apt to find place in, and deform the proceedings of, all human societies. It would seem that your members were, in the general, so absorbed in the search for truth as to forget self. Your proceedings have been grave, courteous, liberal. Differences of opinion have been incentives to renewed and more cautious investigation, rather than provocations to controversy. You, necessarily, admit hypothesis; but the creations of fancy are not permitted to supply the deficiencies of science. You have "loved science for her own sake, and revered her under every form and manifestation;" you "love her, too, personified in young and ardent students of nature," and treat them "not as rivals who are to be feared and shunned, but as successors who merit instruction and assistance." In natural history, you have remembered and acted upon the old maxim, that "a single species, thoroughly and systematically studied, will teach more than a hundred cursorily examined." And then, above all, in all your proceedings, and in all your investigations, you have recognized and respected the great yearning of the common soul for God! In this great presence, I feel that I am nothing, — a mere smatterer, a sciolist; but, perhaps, for that very reason, I am the fitter to express that common yearning of all who think. That there should be a man without an appetite for knowledge is incredible. But the appetite grows with what it feeds on; it is as insatiable as death, and has infinity before it. The astronomer of our day may smile at the littleness of the achievements of the Chaldean watchers of the stars, for he, aided by science, has resolved the milky-way and peered far out into space. But he is not "mad;" he cannot be "undevout;" he must feel how minute he is, — how infinitesimal his great scope of vision is in space, which can be bounded only by God. And he who, with the microscope, will spy into the region of life, — though he too acquire a subliming knowledge, — he finds that, below the lowest deep he reaches, there is a lower depth, and the great secret of life, its essence, remains impenetrable. Knowledge is ecstatic in enjoyment; but man's capacity for it, whatever his attainments, is never satisfied. The true philosopher — the searcher after all truth, and finder of some truth — must feel that the pebbles he has picked up on the strand are poor; and, in the troubles and perplexities which surround him, yea, from the very love of science, comes that longing for, and belief in, the great Knower,— the Creator,— not a Brahma, who, having made and imposed laws upon all things, leaves them and remains aloof, absorbed in a contemplation of his own perfection, but a personal God, one who does illuminate, forgive, pity, and bless; the God whom all Christians worship and adore. The fact, then, that science as pursued by you is Christianizing forms one of its strongest titles to the approbation of the just.

Buffalo is a busy town. Work reigns in it, — our present master. Few of us have leisure for the pursuits of recondite science, and we have just commenced adorning our city with the triumphs of painting and sculpture, and possess but germs of public libraries and cabinets of science. Antiquity has not hallowed our edifices, and, with but few exceptions, they were built only for our day. We have, in the material way, nothing grand or impressive to show you. Our jewels are our liberal, big-hearted citizens; and, if you will but note it, you will find everywhere in our good city a deep respect for literature, for art, for science, and a longing to make it as famous in letters as it is prosperous in commerce and manufactures. Among young and old, — our merchants, our bankers, our manufacturers, our hard-handed artificers, — you will find people who can admire and appreciate you, and who yearn for sound science. They welcome you with their heart of hearts; they look to this Association, with confidence, for countenance and aid in their endeavors to know; they hope that you will carry hence respect for Buffalo, that your remembrance of this session will be pleasant; they expect and believe that your meeting will give an impetus to this great city in the pursuit of science, and form an era in its history. May these high hopes be realized! May the good God, the author of all knowledge, bless you in all things, and make this session of the American Association for the Advancement of Science peculiarly fruitful of glory to Himself, and of good unto our country and mankind.

The address of Judge Clinton was responded to by President Barnard, in behalf of the American Association, as follows: —

Mr. Clinton, — It affords me, sir, unusual satisfaction to express to you, and, through you, to the members of the Association over which you have the honor to preside, and to the citizens of Buffalo generally, the deep sense of your courtesy and hospitality which is entertained by the members of this body. This welcome is the more grateful, inasmuch as we come to you with none of those claims which seem usually most imposing to the imagination of men. We possess neither place nor power. We are neither rulers of men, nor judges, nor law-makers; nor yet is it our privilege to belong to that fourth estate, more powerful, perhaps, than all the rest, which holds an almost resistless sway over the opinion of men, — the public press. Neither can we put forward the pretensions which wealth often so ostentatiously prefers, and which commonly find so prompt and undisputed recognition among mankind. The votaries of science rarely reap any other rewards in this world than the satisfaction which their labors themselves afford. We possess, in fact, but one single recommendation to your kind consideration, — a recommendation which has weight in proportion as minds are elevated by enlightenment and ennobled by generosity, — it is the love of truth, and honest zeal in its pursuit. And in the fact that, with but this single recommendation, we have met at your hands so cordial and warm a reception, we have the most satisfactory assurance and evidence of the enlightenment of your views and the generosity of your sentiments.

Other considerations heighten the gratification which your welcome has afforded us.

This beautiful city of yours is one of the marvellous growths of which our country presents so many striking examples, but among which Buffalo is especially conspicuous. It has sprung from nothing to its present greatness entirely within the present century. Indeed, long after the century began, it had hardly a title to be called a town, — it was but a mere landing upon the shores of Lake Erie. Its wonderful expansion, its astonishing increase in population and wealth, dates back hardly forty years, — dates back only to the completion of that magnificent line of internal, artificial navigation, by which the lakes were married to the Atlantic. Within that brief period, — so very brief considered as a portion of a people's history, — there has been heaped up here an amount of wealth so great, that though it may be written down in the figures of statistical tables, the mind fails to form any clear conception of it. This immensity of wealth is evidenced in the throng of vessels which crowd your wharves, in the numberless deeply-freighted barges which continually leave here for the interior, in your magnificent elevators and spacious warehouses, and in all the other evidences of a vast commercial activity. It is by these instrumentalities that there is ever kept in motion that ceaseless stream of material wealth, which, gathered throughout all the great West and North-west, seeks the seaboard through this channel; while through the same channel there comes back a similar returning flood, which spreads itself out all over the West. The stir of business, the pressure of the crowd, the activity of movement which fills your streets, can hardly find a parallel anywhere on the continent, unless it be in the great commercial metropolis itself.

Under these circumstances, it is easy to perceive how great are the temptations which beset your people to become absorbed in the pursuit of wealth, to be swallowed up in the material, and to forget what concerns the intellectual advancement of the race. That they have escaped this danger is, however, evident, from the fact of the existence and the healthy activity among you of the Association which you, sir, so worthily represent, which is already honorably known in sister cities in our land, and is destined to be known no less honorably wherever, throughout all the world, science is held in high esteem; an institution devoted to pursuits identical with those in which we are interested.

It gratifies us, therefore, peculiarly, to know that you receive us not merely as entertainers, but as sympathizers and collaborators. And if this meeting is to be a success, — if, when the history of this Association is written, the historian shall dwell with special interest upon what is here to take place, — it will doubtless be owing to the fact that we here enjoyed the benefit of your counsels, and the aid of your substantial contributions.

Once more, sir, in behalf of the Association, permit me to tender you my thanks for the cordiality of your welcome.

After an interval of a few moments, Professor Barnard said that the meeting, originally appointed to have been held at Nashville, Tenn., now assembled after an adjournment of six years. In the intervening period many events have occurred of great interest to the country, and which have had a great effect upon the Association. The General Secretary (Professor W. P. Trowbridge) was not present, owing to some prior business engagements in the Novelty Iron Works, at New York, over which he had charge in the absence of the President of the Works. They were also deficient in a Vice-President (Dr. R. W. Gibbes), of whom no accounts have been received since the return of peace. His residence was in one of the Southern States (South Carolina), and the Professor said he had not been able to communicate with him, though he had sent him several communications. It would be necessary to fill these vacancies.

The Professor alluded to an eminent state geologist (Professor Edward Hitchcock, of Massachusetts), as one of the early geologists, who, if he might not be called the founder of the Association, is admitted to have been one of its fathers. Another distinguished member, who had done as much as any other man to promote the interests of science, was also gone, — the founder of the American *Journal of Art and Science* (Professor B. Silliman, of Yale College), a work he had sustained for many years under difficulties that can hardly be appreciated. Still another great member was lost; he who, at his country's call, left the field of science for that of Mars, and at length demonstrated the sincerity of his patriotism by offering up his life on the altar of his country.[1]

Professor Barnard presented the regrets of Professor Agassiz, of Harvard College, who had just returned after a residence of eighteen months in the empire of Brazil. Owing to the condition of his domestic and personal affairs, he found it necessary to remain at home. Professor Joseph Henry, of the Smithsonian Institution at Washington, was also unavoidably absent. Many others sent word that they could not afford the expenses incurred in travelling; for such had been the increase in living, without a corresponding increase in the salaries of men of science, that they were left without adequate means.

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[1] Gen. O. M. Mitchell.

He spoke of the southern members, saying, science is cosmopolitan; and, whatever may be the difference of opinion concerning religion, politics, or any other subject, yet, upon pure, positive science there is always a chance for harmony and unanimity of sentiment among the devotees of this noble branch of human inquiry; there is a common ground, and upon this it might be hoped to gather men of the north and south; and he expressed the wish that the Association would become one of the instruments by which the lacerated wounds of the country might be healed. "I trust that some of our friends, from whom we have been divided, may yet appear. If they do not on this occasion, I doubt not they will at some future meeting."

The Association then proceeded to the election, by ballot, of a General Secretary, which resulted in the choice of Professor ELIAS LOOMIS, of Yale College. A ballot was then taken for Vice-President, and Dr. A. A. GOULD was elected.

The Association then proceeded to elect six additional members of the Standing Committee, according to Rule 6 of the Constitution. The names of those chosen are printed elsewhere with the other members of that committee.

On Friday morning, August 17th, the citizens of Buffalo were invited to meet with the members of the Association and listen to a paper by Mrs. Almira L. Phelps, on the "Scientific and Religious Character of Edward Hitchcock." After this paper had been read by Dr. Chester, an address on "Scientific Education" was delivered by Professor J. P. Cooke.

On Saturday morning, in general meeting, the President invited Hon. Millard Fillmore to take the chair while he offered certain resolutions, which he prefaced with the following remarks:

MR. CHAIRMAN, — The paper which I hold in my hand contains resolutions which I am sure will command the ready assent and concurrence of all who are present, expressive of what I believe to be the feelings of the Association, in view of the cause which prevents the attendance at this meeting of one of our most honored and esteemed associates, Professor Alexander Dallas Bache, Chief of the Coast Survey of the United States. I might have left the duty of presenting them to be discharged by abler hands, were it not that powerful personal considerations, my warm affection for the subject of the resolutions, and my deep sense of obligations toward him for many acts of kindness during an unwavering friendship of long continuance, impel me to claim it for myself. I have no purpose to enter here upon a review of the honorable life-history of Professor Bache. The day is yet, I trust, far distant when such a record will have to be made up. It is sufficient to remark that, in the course of a brilliant career, extending through more than thirty years, in which he has distinguished himself in many fields of labor, it may be said with truth of him, as it was said of Goldsmith, that he has touched nothing which he has not adorned. As an educationist, as a physicist, as a civil engineer, as the director of one of the most magnificent goedetic works which the world has seen, he has occupied, and still occupies, by the common consent of his countrymen and of civilized mankind, a place in the front rank of the votaries of science. As a citizen, his record is without a blemish; as a patriot, his loving zeal is known of all who have come into contact with him; as a philanthropist, his influence, through his connection with our noble Sanitary Commission, has been felt throughout all the vast armies sent forth by the nation to crush the recent gigantic rebellion, from the general commanding in chief down to the humblest private. It is the first time, since the foundation of the Association, that we miss his genial presence and fail to hear his encouraging voice in these our pleasant and profitable reunions. I think there is no individual in the entire circle of its present or past membership to whom the Association would be disposed more promptly, more willingly, or more feelingly to pay the tribute of honor and sympathy which these resolutions propose. The resolutions are as follows: —

*Whereas*, Providence has seen fit to afflict this Association, by visiting one of its most distinguished members, Professor Alexander Dallas Bache, Chief of the Coast Survey of the United States, with a malady which deprives the Association, for the first time since its foundation, of the pleasure of his presence in its meetings, and of the benefit of his judicious counsels and energetic coöperation; be it, therefore,

*Resolved*, That the Association sincerely condole with Professor Bache in his present illness, and earnestly desire and hope that he may be speedily restored to health and usefulness, and may yet continue for many years to honor the country which he has so long and so faithfully served.

*Resolved*, That the Association deeply deplores the loss to American science resulting from the enforced suspension of the labors of their eminent associate, by which labors its treasures have heretofore been so greatly enriched, and its advancement so actively promoted.

*Resolved*, That the Association extend to Mrs. Bache their heartfelt sympathies under her present painful trial, and beg leave respectfully to express their admiration of the tenderness and devotion with which she has watched over her suffering companion, and of the beautiful illustration which she has thus given of the noblest virtues which adorn her sex.

*Resolved*, That the General Secretary of the Association be instructed to transmit a copy of these resolutions to Professor and Mrs. Bache.

The Association voted to hold the next meeting at Burlington, Vermont, beginning on Wednesday, August 21.

The officers elected for the next meeting are, Professor J. S. NEWBERRY, of New York, President; Dr. WOLCOTT GIBBS, of Cambridge, Vice-President; Professor C. S. LYMAN, of New Haven, General Secretary; Dr. A. L. ELWYN, of Philadelphia, Treasurer.

On Monday evening, the business of the Association being finished, and a motion to adjourn prevailing, the President closed the meeting with the following address: —

GENTLEMEN OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE, — Before pronouncing you adjourned, I desire to congratulate you — and I do so with the highest satisfaction — upon the triumphant success of your meeting in Buffalo. It has been a success in every point of view in which it can be considered. It has been a success in respect to attendance; for though, on some former occasions, there has been an actual numerical superiority, yet, when we consider the economical difficulties of the present time, the uncertainty, which till very recently existed, as to the date of the meeting, and the total absence which, however much it may be regretted, was not, perhaps, wholly unlooked for, of all our southern brethren, we have reason to be greatly encouraged at the visible strength of the phalanx which has here spontaneously gathered together.

It has been a success in respect to the evidences of interest in our revived organization manifested by many of those of our brotherhood whom unavoidable necessity has constrained to be absent on the present occasion, — evidences which I have had the pleasure of laying before you in the form of communications, written and oral, from some of the most distinguished of those whose names stand conspicuous upon the records of our former meetings.

It has been a success in respect to the unbroken harmony which has characterized all our proceedings, the admirable courtesy which has marked all our debates, the kindness of feeling between individuals, which has gathered strength with each day's continuance of intercourse, and the increased respect which we have learned to feel for each other.

It has been a success in respect to the number of valuable papers which have been presented, the variety of their topics, the vigor of thought which many of them have evinced, and the clearness of the method displayed in their preparation.

It has been a decided success as it regards the interest of the discussions which the papers have elicited, the discriminating criticism which they have provoked, the ability and eloquence with which their theories have been assailed and defended, and the stimulus, which, through all these influences, has been given to activity and indedependence of thought.

But it has been finally and signally a success, in that it has been held in the midst of a generous and appreciative people, whose many kindnesses have literally overwhelmed the Association as a body and its individual members. There is nothing which you could desire which the noble-hearted citizens of Buffalo have not placed at your disposal. They have thrown open freely to you their dwellings, they have heaped their tables with luxuries for your enjoyment, they have abolished for you the rigid rules by which the privacy of their great industrial establishments is ordinarily guarded, and made you free to inspect at your ease their mills, their manufactories, their warehouses, their elevators, and all the other great instrumentalities by which wealth is here accumulated and exchanged. And, beside all this, they have afforded you opportunity to enjoy the grand aspects of nature which this vicinity presents, and have introduced you to the loveliness and majesty of their noble lake, and the beauties of their magnificent river. There has been no moment of your time which they have permitted to run to waste, or which their large-hearted hospitality has failed to fill up with their assiduous kindnesses and their flattering attentions. In this respect, then, surely the success of your meeting has exceeded everything that the most exacting among you could have anticipated or desired.

For these things you will, first of all, surely give thanks to that glorious Providence which has cast your lines in so pleasant places, and has so signally prospered the works of your hands.

And in the next place you will all of you feel — and as you have opportunity you will individually express, as I here desire to do for you as a body, and as you have already done in your resolutions — your deep sense of obligation to this noble-minded, generous, cultivated, and enlightened people, for all the kindnesses which they have literally showered upon you, and without which your meeting, instead of inspiring and cheering, might have sent you back to your homes discouraged and disappointed.

Gentlemen of the Association, — with my sincerest wishes for your continued welfare, I now pronounce your Association adjourned, to reassemble at the city of Burlington, Vt., on the 21st day of August, 1867.

Most of the members in attendance at the Buffalo meeting availed themselves of the private hospitality so generously offered by many families in the city; a hospitality readily accepted on account of the accidental crowding of the hotels at the time, but made doubly welcome by the cordiality with which it was offered and maintained. Receptions were also given to the members of the Association, and their ladies, by Col. W. A. Bird, Capt. E. P. Dorr, Hon. N. K. Hall, and O. G. Steele, Esq. On Saturday afternoon the steamer Atlantic was placed at the disposal of the Local Committee by T. D. Dole, Esq., and the members of the Association, with their ladies, made an agreeable excursion on Lake Erie and Niagara river, in company with many ladies and gentlemen of Buffalo. On Tuesday, August 21, after the close of the scientific sessions of the Association, the members, with their hosts and other citizens of Buffalo, made an excursion on the Erie and Niagara Railway to Niagara Falls, where they were most generously entertained by Mr. and Mrs. Bush at their cottage on the Canada side of the river.

## RESOLUTIONS ADOPTED.

*Resolved,* That a Committee of three be appointed by the President of this Association, whose duty it shall be to memorialize Congress in favor of printing the Annual Reports of the Hydrographical Survey of the Lakes, *in a separate form.*

*Resolved,* That said Committee is also instructed to make application to the proper authorities for obtaining an increase in the appropriation for the Scientific Purposes of the Survey, with special reference to Meteorology, Fluctuations of Level, and the general Drainage of the Lake Country.

*Resolved,* That the American Association for the Advancement of Science approves of the appointment of a Scientific Commission to attend and study the Universal Exposition to be held in Paris in 1867, and that it be urged upon Congress to provide the necessary means to enable the Commission to prepare for publication full reports upon the recent applications of Science to the Arts, as set forth in the Exposition, in a form suitable for circulation throughout the country.

*Resolved,* That a Committee be appointed to memorialize the Legislature of West Virginia in favor of a geological survey of that State.

*Resolved,* That the Association welcomes with great satisfaction the recent legislation of Congress authorizing the employment of metric weights and measures, and taking steps facilitating the introduction of the decimal system, and that it congratulates the nation upon this important change, and hopes for further progress in the same direction.

*Resolved,* That copies of these resolutions be sent to the Hon. Secretary of the Treasury and to the Chairman of the Special Committees of the Senate and the House of Representatives by which the recent laws were reported.

## VOTES OF THANKS.

*Resolved,* That the members of this Association feel unwilling to separate without expressing their sincere thanks to the Committee of Reception, and their high appreciation of the efforts made by the citizens of Buffalo to render this meeting both efficient and comfortable.

They have been assiduous and untiring in their efforts to facilitate our business, and by their elegant personal attentions have made this visit in all respects agreeable and attractive.

*Resolved,* That the thanks of the Association be presented to the gentlemen of the Committee of Reception, and especially to Col. Wm. A. Bird, its chairman; to Capt. E. P. Dorr, a member of that committee, and to T. D. Dole, Esq., Manager of the New York Central Line of Propellers, for the delightful excursion on the steamer Atlantic, Saturday afternoon; also to Wm. A. Thompson, Esq., Vice-President of the Erie and Niagara Railway, for his polite invitation to the Association to unite in an excursion to Niagara Falls to-morrow morning, which invitation we accept with gratitude and pleasure.

*Resolved,* That the hearty thanks of this Association be presented to the Young Men's Association of Buffalo for their hospitable and generous welcome, and for all the facilities which they have so kindly placed at our disposal.

*Resolved,* That the thanks of the Association be presented to the Buffalo Society of Natural Sciences, the Buffalo Historical Society, and the Buffalo Society of the Fine Arts, for their sympathy, and for the liberality with which they have thrown open their valuable and interesting collections for our examination and use; and that we desire to join with our thanks an expression of our cordial wishes for their continued success and usefulness.

*Resolved,* That the thanks of the Association are due to the Press of Buffalo and to the New York *Tribune* for the very full and accurate reports given of its proceedings.

*Resolved,* That the thanks of the Association be presented to President Barnard for the dignity and ability with which he has presided over its sessions during the present meeting.

## REPORT OF THE PERMANENT SECRETARY.

THIS report includes the whole interval of time from the commencement of the Newport meeting (August 1st, 1860) to that of the Buffalo meeting (August 15th, 1866). The usual duties of the office were discharged until the publication and distribution of the Newport volume (January 1, 1861). Since then, on account of the interruption in our meetings, the most onerous duties of the office have been suspended, and the Permanent Secretary has had nothing to do except to conduct the correspondence of the Association and to carry forward the exchanges of publications.

By a standing vote of the Association, a salary of five hundred dollars ($500) a year is paid to this officer. The undersigned has understood this vote as *not* applying to the interval during which the meetings of the Association were suspended. During the present meeting, however, the Association have, by special vote, paid to the Permanent Secretary at the rate of about forty dollars a year for services performed since January 1, 1861.

In renewing the meetings of the Association at a place not contemplated by the members present at its last meeting, and for which no Local Committee and no Local Secretary had been appointed, it became necessary for the Permanent Secretary to assume the duties of the Local Secretary and to issue the circular for the Buffalo meeting.

The Association now consists of six hundred and twenty-seven members. Thirty-six were added at Newport and two hundred and seventy-one were then struck off on account of delinquencies in the payment of assessments: their aggregate indebtedness to the Association being twenty-four hundred and thirty nine dollars ($2439).

The financial condition of the Association is as follows: —

Between August 1, 1860 (the first day of the Newport meeting) and August 15, 1866 (the first day of the Buffalo meeting), the income has amounted to thirteen hundred and forty-six dollars and fifteen cents ($1346.15); of which one hundred and sixty-three dollars ($163) came from the sale of copies of Proceedings, and the balance from the annual assessments.

The expenses of the Association for the same time have been eighteen hundred and thirty-six dollars and sixty-nine cents ($1836.69), which may be classified in general as follows: —

| | |
|---|---|
| Cost of paper, printing, etc., for the Newport volume of Proceedings, nine hundred and seventy-two dollars and forty cents, . . . . . . . . . . | $972.40 |
| Charges connected with the Newport meeting, forty-three dollars and seventy-five cents, . . . . | 43.75 |
| Charges connected with the notifications for the Buffalo meeting, thirty-dollars, . . . . . . . | 30.00 |
| Salary of the Permanent Secretary, five hundred dollars, | 500.00 |
| Postage, Express charges, and other expenses, ninety dollars and fifty-four cents, . . . . . . . | 90.54 |
| Appropriation to the Permanent Secretary, . . . | 200.00 |

The particular items may all be found in the cash account of the Secretary, which is herewith submitted as a part of his report. The balance in the hands of the Permanent Secretary, August 15, 1860, is sixty-six dollars and forty-four cents ($66.44). The balance in the hands of the Treasurer is five hundred dollars ($500).

JOSEPH LOVERING,
*Permanent Secretary.*

BUFFALO, August 15, 1866.

## REPORT OF THE AUDITOR.

This certifies that I have this day examined the above account of the Permanent Secretary, comparing the credits with the cash account and receipt-book and the debits with the several vouchers, and find the whole correct, and the sum of sixty-six dollars and forty-four cents credited to the next account ($66.44).

[Signed] B. A. GOULD, *Auditor.*

BUFFALO, August 20, 1867.

## CASH ACCOUNT OF THE

**Dr.** AMERICAN ASSOCIATION *in*

| | |
|---|---|
| Bradford's bill for care of programmes, | $15.00 |
| Mackintosh's services as clerk, | 25.00 |
| Printing railroad circular, | 2.50 |
| Folding and stitching programmes, | 1.25 |
| Grant & Warren, for paper, | 324.52 |
| Rice & Kendall, for paper, | 9.00 |
| Welch & Bigelow, for printing, | 11.00 |
| Kilbourn & Mallory, for wood-cuts, | 51.00 |
| Paper for covers to Newport volume, | 1.20 |
| Rice & Kendall, for paper, | 6.41 |
| Allen & Farnham, for printing, | 353.21 |
| Salary of Permanent Secretary, | 500.00 |
| Bradley & Dayton, for binding, | 64.31 |
| J. Bien, for printing Bache's plates, | 149.50 |
| Smithsonian Institution, for freight, | 11.75 |
| Postage and discount, | 43.60 |
| Express charges, | 50.44 |
| Ripley's bill, for printing Buffalo circulars, | 7.00 |
| Printed envelopes for Buffalo circulars, | 10.00 |
| Permanent Secretary, for five years, | 200.00 |
| | $1,836.69 |
| Balance to next account, | 66.44 |
| | $1,903.13 |

## PERMANENT SECRETARY.

| *Account with* JOSEPH LOVERING. | Cr. |
|---|---|
| Balance from last account, . . . . . | $389.98 |
| Assessments (from 879 of old cash-book to 183 of new cash book), including sale of Proceedings, . . . | 1,346.15 |
| Received from the Treasurer, . . . . . | 167.00 |
| | $1,903.13 |

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# PROCEEDINGS

OF

# THE AMERICAN ASSOCIATION

FOR THE

# ADVANCEMENT OF SCIENCE.

## SIXTEENTH MEETING,

HELD AT BURLINGTON, VERMONT,

AUGUST, 1867.

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CAMBRIDGE:
PUBLISHED BY JOSEPH LOVERING.
1868.

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July 22

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EDITED BY

**JOSEPH LOVERING,**

*Permanent Secretary*

BOSTON:
F. B. Dakin, Printer.

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# OFFICERS OF THE ASSOCIATION

AT THE

# BURLINGTON MEETING.

J. S. Newberry, *President.*
Wolcott Gibbs, *Vice-President.*
Joseph Lovering, *Permanent Secretary.*
C. S. Lyman, *General Secretary.*
Dr. A. L. Elwyn, *Treasurer.*

## *Standing Committee.*

### EX-OFFICIO.

J. S. Newberry,
Wolcott Gibbs,
Joseph Lovering,
C. S. Lyman,
F. A. P. Barnard,
A. A. Gould,*
Elias Loomis,
A. L. Elwyn.

### AS CHAIRMEN OF THE SECTIONAL COMMITTEES.

J. W. Dawson,
Charles Whittlesey.

### FROM THE ASSOCIATION AT LARGE.

E. N. Horsford,
J. B. Angell,
Alexis Caswell,
B. A. Gould,
J. H. Coffin,
G. W. Hough.

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* Died before the meeting.

## *Local Committee.*

Torrey E. Wales, *Chairman.*
Edward Hungerford, *Secretary.*
James W. Hickock, *Treasurer.*

Albert L. Catlin,
G. G. Benedict,
M. H. Buckham,
Edward W. Peck,
D. D. Howard,
Henry Loomis,
George H. Bigelow,
Lawrence Barnes,
George F. Edmands,
D. C. Linsley.

## *Committee of Arrangements.*

Edward W. Peck,
Albert L. Catlin,
James W. Hickok.

# SPECIAL COMMITTEES.

## A. Committees continued from former Meetings.

### 1. *Committee to Report in Relation to Uniform Standards in Weights, Measures, and Coinage.*

John Torrey,
H. A. Newton,
Joseph Henry,
Wolcott Gibbs,
Benjamin Peirce,
John LeConte,
W. B. Rogers,
J. E. Hilgard,
John F. Frazer,
J. H. Gibbon,
B. A. Gould,
J. L Smith.

## B. New Committees.

### 1. *Committee to Audit the Accounts of the Permanent Secretary and the Treasurer.*

B. A. Gould,
C. S. Lyman.

### 2. *Committee with whom the Permanent Secretary may advise in regard to the publication of the Burlington Proceedings.*

B. A. Gould,
W. B. Rogers.

### 3. *Committee to act with the Standing Committee in nomination of Officers for the Chicago Meeting.*

Section A.
A. P. Rockwell,
E. L. Youmans,
O. N. Rood,
Charles F. Chandler.

Section B.
A. H. Worthen,
John Torrey,
J. W. Dawson,
L. H. Morgan.

# OFFICERS OF THE CHICAGO MEETING.

B. A. Gould, *President.*
Charles Whittlesey, *Vice-President.*
Joseph Lovering, *Permanent Secretary.*
A. P. Rockwell, *General Secretary.*
A. L. Elwyn, *Treasurer.*

## *Standing Committee.*

B. A. Gould,
Charles Whittlesey,
Joseph Lovering,
A. P. Rockwell,
J. S. Newberry,
Wolcott Gibbs,
C. S. Lyman,
A. L. Elwyn,

## *Local Committee.*

William Stimpson, *Secretary.*

Edmund Andrews,
John F. Beaty,
J. V. Z. Blaney,
E. W. Blatchford,
William Bross,
E. S. Chesbrough,
Edward Daniels,
W. E. Doggett,
J. W. Foster,
Walter Hay,
E. B. McCogg,
John H. Rauch,
T. H. Safford,
J. Young Scammon,
E. H. Sheldon,
George C. Walker,
John M. Woodworth.

## MEETINGS OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

| Meeting. | Date. | Place. | President. | Vice-President. | General Secretary. | Permanent Secretary. | Treasurer. |
|---|---|---|---|---|---|---|---|
| 1st, | Sept. 20, 1848, | Philadelphia, Pa. | W. C. Redfield, | | Walter R. Johnson, | | Jeffries Wyman. |
| 2d, | Aug. 14, 1849, | Cambridge, Mass., | Joseph Henry, | | E. N. Horsford, | | A. L. Elwyn. |
| 3d, | March, 12, 1850, | Charleston, S. C., | A. D. Bache,* | | L. R. Gibbes,* | | St. J. Ravenel.* |
| 4th, | Aug. 19, 1850, | New Haven, Ct., | A. D. Bache, | | E. C. Herrick, | | A. L. Elwyn. |
| 5th, | May 5, 1851, | Cincinnati, Ohio, | A. D. Bache, | | W. B. Rogers, | S. F. Baird, | A. L. Elwyn. |
| 6th, | Aug. 19, 1851, | Albany, N. Y., | Louis Agassiz, | | W. B. Rogers, | S. F. Baird, | A. L. Elwyn. |
| 7th, | July 28, 1853, | Cleveland, Ohio, | Benj. Peirce, | | J. D. Dana, | S. F. Baird, | A. L. Elwyn. |
| 8th, | April 26, 1854, | Washington, D. C., | J. D. Dana,* | | J. Lawrence Smith, | Joseph Lovering, | J. L. LeConte.* |

* In the absence of the regular officer.

## MEETINGS OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

| Meeting. | Date. | Place. | President. | Vice-President. | General Secretary, | Permanent Secretary. | Treasurer. |
|---|---|---|---|---|---|---|---|
| 9th, | Aug. 15, 1855, | Providence, R. I., | John Torrey, | | Wolcott Gibbs, | Joseph Lovering, | A. L. Elwyn. |
| 10th, | Aug. 20, 1856, | Albany, N. Y., | James Hall, | | B. A. Gould, | Joseph Lovering, | A. L. Elwyn. |
| 11th, | Aug. 12, 1857, | Montreal, C. E., | J. W. Bailey, | Alexis Caswell, | John LeConte, | Joseph Lovering, | A. L. Elwyn. |
| 12th, | April 28, 1858, | Baltimore, Md., | Alexis Caswell,* | John E. Holbrook, | W. M. Gillespie, | Joseph Lovering, | A. L. Elwyn. |
| 13th, | Aug. 3, 1859, | Springfield, Mass., | S. Alexander, | Edward Hitchcock, | William Chauvenet, | Joseph Lovering, | A. L. Elwyn. |
| 14th, | Aug. 1, 1860, | Newport, R. I., | Isaac Lea, | B. A. Gould, | Joseph LeConte, | Joseph Lovering, | A. L. Elwyn. |
| 15th, | Aug. 15, 1867, | Buffalo, N. Y., | F.A.B. Barnard, | A. A. Gould, | Elias Loomis, | Joseph Lovering, | A. L. Elwyn. |
| 16th, | Aug. 21, 1868, | Burlington, Vt., | J. S. Newberry, | Wolcott Gibbs, | C. S. Lyman, | Joseph Lovering, | A. L. Elwyn. |

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* In the absence of the regular officer.

# CONSTITUTION OF THE ASSOCIATION.*

## OBJECTS.

THE Association shall be called "The American Association for the Advancement of Science." The objects of the Association are, by periodical and migratory meetings, to promote intercourse between those who are cultivating science in different parts of the United States, to give a stronger and more general impulse, and a more systematic direction, to scientific research in our country, and to procure for the labors of scientific men increased facilities and a wider usefulness.

## MEMBERS.

RULE 1. Members of scientific societies, or learned bodies, having in view any of the objects of this Association, and publishing transactions, shall be considered members on subscribing these rules.

RULE 2. Collegiate professors, also civil engineers and architects, who have been employed in the construction or superintendence of public works, may become members on subscribing these rules.

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* Adopted August 25, 1856, and ordered to go into effect at the opening of the Montreal Meeting. Amended at Burlington, August, 1867

RULE 3. Persons not embraced in the above provisions may become members of the Association upon recommendation in writing by two members, nomination by the Standing Committee, and election by a majority of the members present.

### OFFICERS.

RULE 4. The officers of the Association shall be a President, Vice-President, General Secretary, Permanent Secretary, and Treasurer. The President, Vice-President, General Secretary, and Treasurer shall be elected at each meeting for the following one; — the three first-named officers not to be re-eligible for the next two meetings, and the Treasurer to be re-eligible as long as the Association may desire. The Permanent Secretary shall be elected at each second meeting, and also be re-eligible as long as the Association may desire.

### MEETINGS.

RULE 5. The Association shall meet, at such intervals as it may determine, for one week, or longer, — the time and place of each meeting being determined by a vote of the Association at the previous meeting; and the arrangements for it shall be intrusted to the officers and the Local Committee.

### STANDING COMMITTEE.

RULE 6. There shall be a Standing Committee, to consist of the President, Vice-President, Secretaries, and Treasurer of the Association, the officers of the preceding year, the permanent Chairman of the Sectional Committees, after these shall have been organized, and six members present from the Association at large, who shall have attended any of the previous meetings, to be elected upon open nomination by ballot on the first assembling of the Association. A majority of the whole number of votes cast to elect. The General Secretary shall be Secretary of the Standing Committee.

The duties of the Standing Committee shall be, —

1. To assign papers to the respective sections.

2. To arrange the scientific business of the general meetings, to suggest topics, and arrange the programmes for the evening meetings.

3. To suggest to the Association the place and time of the next meeting.

4. To examine, and, if necessary, to exclude papers.

5. To suggest to the Association subjects for scientific reports and researches.

6. To appoint the Local Committee.

7. To have the general direction of publications.

8. To manage any other general business of the Association during the session, and during the interval between it and the next meeting.

9. In conjunction with four from each Section, to be elected by the Sections for the purpose, to make nominations of officers of the Association for the following meeting.

10. To nominate persons for admission to membership.

11. Before adjourning, to decide which papers, discussions, or other proceedings shall be published.

### SECTIONS.

RULE 7. The Association shall be divided into two Sections, and as many sub-Sections as may be necessary for the scientific business, the manner of division to be determined by the Standing Committee of the Association. The two Sections may meet as one.

### SECTIONAL OFFICERS AND COMMITTEES.

RULE 8. On the first assembling of the Section, the members shall elect upon open nomination a permanent Chairman and Secretary, also three other members, to constitute, with these officers, a Sectional Committee.

The Section shall appoint, from day to day, a Chairman to preside over its meetings.

RULE 9. It shall be the duty of the Sectional Committee of each Section to arrange and direct the proceedings in their Section; to ascertain what communications are offered; to assign the order in which these communications shall appear, and the amount of time which each shall occupy.

The Sectional Committees may likewise recommend subjects for systematic investigation by members willing to undertake the researches, and to present their results at the next meeting.

The Sectional Committee may likewise recommend reports on particular topics and departments of science, to be drawn up as occasion permits, by competent persons, and presented at subsequent meetings.

## REPORTS OF PROCEEDINGS.

RULE 10. Whenever practicable, the proceedings shall be reported by professional reporters, or stenographers, whose reports are to be revised by the Secretaries before they appear in print.

## PAPERS AND COMMUNICATIONS.

RULE 11. No paper shall be placed in the programme, unless admitted by the Sectional Committee; nor shall any be read, unless an abstract of it has been previously presented to the Secretary of the Section, who shall furnish to the Chairman the titles of papers, of which abstracts have been received.

RULE 12. The author of any paper or communication shall be at liberty to retain his right of property therein, provided he declares such to be his wish before presenting it to the Association.

RULE 13. Copies of all communications, made either to the General Association or to the Sections, must be furnished by the authors; otherwise only the titles, or abstracts, shall appear in the published proceedings.

RULE 14. All papers, either at the general or in the sectional meetings, shall be read, as far as practicable, in the order in which they are entered upon the books of the Association; except that those which may be entered by a member of the Standing Committee of the Association shall be liable to postponement by the proper Sectional Committee.

RULE 15. If any communication be not ready at the assigned time, it shall be dropped to the bottom of the list, and shall not be entitled to take precedence of any subsequent communication.

RULE 16. No exchanges shall be made between members without authority of the respective Sectional Committees.

### GENERAL AND EVENING MEETINGS.

RULE 17. The Standing Committee shall appoint any general meeting which the objects and interests of the Association may call for, and the evenings shall, as a rule, be reserved for general meetings of the Association.

These general meetings may, when convened for that purpose, give their attention to any topics of science which would otherwise come before the Sections.

It shall be a part of the business of these general meetings to receive the Address of the President of the last meeting; to hear such reports on scientific subjects as, from their general importance and interests, the Standing Committee shall select; also to receive from the Chairman of the Sections abstracts of the proceedings of their respective Sections; and to listen to communications and lectures explanatory of new and important discoveries and researches in science, and new inventions and processes in the arts.

### ORDER OF PROCEEDINGS IN ORGANIZING A MEETING.

RULE 18. The Association shall be called to order by the President of the preceding meeting; and this officer having resigned the chair to the President elect, the General Secretary shall then report the number of papers relating to each department which have been registered, and the Association consider the most eligible distribution into Sections, when it shall proceed to the election of the additional members of the Standing Committee in the manner before described; the meeting shall then adjourn, and the Standing Committee, having divided the Association into sections as directed, shall allot to each its place of meeting for the Session. The Sections shall then organize by electing their officers and their representatives in the Nominating Committee, and shall proceed to business.

### PERMANENT SECRETARY.

RULE 19. It shall be the duty of the Permanent Secretary to notify members who are in arrears, to provide the necessary stationery and suitable books for the list of members and titles of papers, minutes of the general and sectional meetings, and for other purposes indicated in the rules, and to execute such other duties as may be directed by the Standing Committee or by the Association.

The Permanent Secretary shall make a report annually to the Standing Committee, at its first meeting, to be laid before the Association, of the business of which he has had charge since its last meeting.

All members are particularly desired to forward to the Permanent Secretary, so as to be received before the day appointed for the Association to convene, complete titles of all the papers which they expect to present during its meeting, with an estimate of the time required for reading each, and such abstracts of their contents as may give a general idea of their nature.

Whenever the Permanent Secretary notices any error of fact or unnecessary repetition, or any other important defect in the papers communicated for publication in the proceedings of the Association, he is authorized to commit the same to the author, or to the proper sub-committee of the Standing Committee for correction.

### LOCAL COMMITTEE.

RULE 20. The Local Committee shall be appointed from among members residing at, or near, the place of meeting for the ensuing year; and it shall be the duty of the Local Committee, assisted by the officers, to make arrangements and the necessary announcements for the meeting.

The Secretary of the Local Committee shall issue a circular in regard to the time and place of meetings, and other particulars, at least one month before each meeting.

### SUBSCRIPTIONS.

RULE 21. The amount of the subscription, at each meeting of each member of the Association shall be two dollars, and one dollar in addition shall entitle him to a copy of the proceedings of the annual meeting. These subscriptions shall be received by the Permanent Secretary, who shall pay them over, after the meeting, to the Treasurer.

The admission fee of new members shall be five dollars, in addition to the annual subscription: and no person shall be considered a member of the Association until this admission fee and the subscription for the meeting at which he is elected have been paid.

RULE 22. The names of all persons two years in arrears for annual dues shall be erased from the list of members; provided that two notices of indebtedness, at an interval of at least three months, shall have been previously given.

### ACCOUNTS.

**Rule 23.** The accounts of the Association shall be audited, annually, by auditors appointed at each meeting.

### ALTERATIONS OF THE CONSTITUTION.

**Rule 24.** No article of this constitution shall be altered, or amended, or set aside, without the concurrence of three fourths of the members present, and unless notice of the proposed change shall have been given at the preceding annual meeting.

### NOTE.

A proposition to rescind Rules 1 and 2 and to alter the phraseology of Rule 3, so as to conform to the proposed amendments, was made at the Burlington meeting, and will come up for final action at the meeting in Chicago.

# RESOLUTIONS

OF A

# PERMANENT AND PROSPECTIVE CHARACTER,

ADOPTED AUGUST 19, 1857.

1. No appointment may be made in behalf of the Association, and no invitation given or accepted, except by vote of the Association or its Standing Committee.

2. The General Secretary shall transmit to the Permanent Secretary for the files, within two weeks after the adjournment of every meeting, a record of the proceedings of the Association and the votes of the Standing Committee. He shall also, daily, during the meetings, provide the Chairman of the two Sectional Committees with lists of the papers assigned to their Sections by the Standing Committee.

3. All printing for the Association shall be superintended by the Permanent Secretary, who is authorized to employ a clerk for that especial purpose.

4. The Permanent Secretary is authorized to put the proceedings of the meetings to press one month after the adjournment of the Association. Papers which have not been received at that time may be published only by title. No notice of articles not approved shall be taken in the published proceedings.

5. The Permanent Chairmen of the Sections are to be considered their organs of communication with the Standing Committee.

6. It shall be the duty of the Secretaries of the two Sections to receive copies of the papers read in their Sections, all sub-sections included, and to furnish them to the Permanent Secretary at the close of the meeting.

7. The Sectional Committees shall meet not later than 9 A. M. daily, during the meetings of the Association, to arrange the programmes of their respective sections, including all sub-sections, for the following day. No paper shall be placed upon these programmes which shall not have been assigned to the Section by the Standing Committee. The programmes are to be furnished to the Permanent Secretary not later than 11 A. M.

8. During the meetings of the Association, the Standing Committee shall meet daily, Sundays excepted, at 9 A. M., and the Sections be called to order at 10 A. M., unless otherwise ordered. The Standing Committee shall also meet on the evening preceding the first assembling of the Association at each annual meeting, to arrange for the business of the first day; and on this occasion three shall form a quorum.

9. Associate members may be admitted for one, two, or three years as they shall choose at the time of admission, — to be elected in the same way as permanent members, and to pay the same dues. They shall have all the social and scientific privileges of members, without taking part in the business.

10. No member may take part in the organization and business arrangement of both the Sections.

# MEMBERS

OF THE

# AMERICAN ASSOCIATION

FOR THE

# ADVANCEMENT OF SCIENCE.

NOTE.—Names of deceased members are marked with an asterisk [*]. The figure at the end of each name refers to the meeting at which the election took place.

## A.

Abbe, Cleveland, Washington, District of Columbia (16).
*Adams, C. B., Amherst, Massachusetts (1).
Adelberg, Justus, New York, New York (15).
Aiken, W. E. A., Baltimore, Maryland (12).
Ainsworth, J. G., Barry, Massachusetts (14).
Albert, Augustus J., Baltimore, Maryland (12).
Alexander, Stephen, Princeton, New Jersey (1).
Allen, E. A. H., New Bedford, Massachusetts (6).
*Ames, M. P., Springfield, Massachusetts (1).
Andrews, E. B., Marietta, Ohio (7).
Angell, James B., Burlington, Vermont (16).
*Appleton, Nathan, Boston, Massachusetts (1).

## B.

*Bache, Alexander D., Washington, District of Columbia (1).
Bacon, John, Jr., Boston, Massachusetts (1).
*Bailey, J. W., West Point, New York (1).
Baird, S. F., Washington, District of Columbia (1).
Bardwell, F. W., Jacksonville, Florida (13).
Barlow, Thomas, Canastota, New York (7).
Barnard, F. A. P., New York, New York (7).
Barnard, Henry, Madison, Wisconsin (12).
Barnard, J. G., Washington, District of Columbia (14).
Barnes, James, Springfield, Massachusetts (5).
Barratt, Joseph, Middletown, Connecticut (13).
Basnett, Thomas, Ottawa, Illinois (8).
Batchelder, J. M., Cambridge, Massachusetts (8).
Beadle, E. R., Hartford, Connecticut (10).
*Beck, C. F., Philadelphia, Pennsylvania (1).
*Beck, Lewis C., New Brunswick, New Jersey (1).
*Beck, T. Romeyn, Albany, New York (1).
Bell, Samuel N., Manchester, New Hampshire (7).
Benedict, G. W., Burlington, Vermont (16).
Bigelow, George H., Burlington, Vermont (16).
*Binney, Amos, Boston, Massachusetts (1).
*Binney, John, Boston, Massachusetts (3).
Bird, William A., Buffalo, New York (15).
Blake, Eli W., Burlington, Vermont (15).
Blake, Eli W., New Haven, Connecticut (1).
*Blanding, William, Rhode Island (1).
*Bomford, George, Washington, District of Columbia (1).
Bouve, Thomas T. Boston, Massachusetts (1).
Bowditch, Henry J., Boston, Massachusetts (2).
Bradford, Isaac, Jacksonville, Florida (14).
Bradish, Alvah, Fredonia, New York (15).
Bradley, L., Jersey City, New Jersey (15).
Brayley, James, Buffalo, New York (15).
Brevoort, J. Carson, Brooklyn, New York (1).
Briggs, A. D., Springfield, Massachusetts (13).
Bross, William, Chicago, Illinois (7).

Brown, Robert D., Jr., Cincinnati, Ohio (11).
Brush, George J., New Haven, Connecticut (11).
Buchanan, Robert, Cincinnati, Ohio (2).
Buck, C. E., New York, New York (15).
*Burnap, G. W., Baltimore, Maryland (12).
*Burnett, Waldo I., Boston, Massachusetts (1).
Butler, Thomas B., Norwalk, Connecticut (10).

## C.

*Carpenter, Thornton, Camden, South Carolina (7).
*Carpenter, William M., New Orleans, Louisiana (1).
Case, Leonard, Cleveland, Ohio (15).
*Case, William, Cleveland, Ohio (6).
Cassels, J. L., Cleveland, Ohio (7).
Caswell, Alexis, Providence, Rhode Island (2).
Cattell, William C., Easton, Pennsylvania (15).
Chadbourne, P. A., Williamstown, Massachusetts (10).
Chapin, A. L., Beloit, Wisconsin (14).
*Chapman, N., Philadelphia, Pennsylvania (1).
Chase, George I., Providence, Rhode Island (1).
*Chase, S., Dartmouth New Hampshire (2).
Chauvenet, William, St. Louis, Missouri (1).
Chesbrough, E. S., Chicago, Illinois (2).
Chester, Albert H., New York, New York (15).
Chester, Albert T., Buffalo, New York (15).
Chittenden, L. E., New York, New York (14).
Churchill, Marlborough, Sing Sing, New York (13).
Clapp, Almon M., Buffalo, New York (15).
*Clapp, Asahel, New Albany, Indiana (1).
*Clark, Joseph, Cincinnati, Ohio (5).
Clark, Henry, Worcester, Massachusetts (14).
Cleaveland, C. H., Cincinnati, Ohio (9).
*Cleveland, A. B., Cambridge, Massachusetts (2).
Clinton, George W., Buffalo, New York (15).
Clum, Henry A., New York, New York (9).
Coakley, George W., New York, New York (5).
Cochran, D. H., Brooklyn, New York (15).
Coffin, C. C., Malden, Massachusetts (13).
Coffin James H., Easton, Pennsylvania (1).

Coffin, John H. C., Washington, District of Columbia (1).
*Cole, Thomas, Salem, Massachusetts (1).
*Coleman, Henry, Boston, Massachusetts (1).
Comstock, C. B., West Point, New York (14).
Conant, Marshall, Washington, District of Columbia (7).
Conkling, Frederick A., New York, New York (11).
Conway, M. D., Cincinnati, Ohio (14).
Copes, Joseph S., New Orleans, Louisiana (11).
Corning, Erastus, Albany, New York (6).
Craig, B. F. Washington, District of Columbia (15).
Cramp, J. M., Acadia College, Nova Scotia (11).
Credner, Herman, New York, New York (15).
Crosby, Alpheus, Salem, Massachusetts (10).
Cummings, Joseph, Middletown, Connecticut (13).

## D.

Dalrymple, Rev. E. A., Baltimore, Maryland (11).
Dana, James, D., New Haven, Connecticut (1).
Danforth, Edward, Troy, New York (11).
Davies, Charles, Fishkill, New York (10).
Davis, James, Jr., Boston, Massachusetts (1).
Dawson, J. W., Montreal, Canada (10).
Dean, Amos, Albany, New York (6).
Dean, George W., Fall River, Massachusetts (15).
*Dearborn, George H. A. S., Roxbury, Massachusetts (1).
*Dekay, James E., New York, New York (1).
Delano, B. L., Boston, Massachusetts (16).
Delano, Joseph C., New Bedford, Massachusetts (5).
Denson, Claudius B., Pittsboro, North Carolina (12).
*Dewey, Chester, Rochester, New York (1).
Dexter, G. M., Boston, Massachusetts (11).
Dinwiddie, Robert, New York, New York (1).
Dixwell, Epes S., Cambridge, Massachusetts (1).
Dobbins, David P., Buffalo, New York (15).
Dorr, E. P., Buffalo, New York (15).
Dow, George W., Chicago, Illinois (13).
Downes John, Washington, District of Columbia (10).
Drowne, Charles, Troy, New York (6).

*Ducatel, J. T., Baltimore, Maryland (1).
Duffield, George, Detroit, Michigan (10).
*Dumont, A. H., Newport, Rhode Island (14).
*Duncan, Lucius C., New Orleans, Louisiana (10).
*Dunn, R. P., Providence, Rhode Island (14).
Dunn, T. C., Newport, Rhode Island (14).
Dyer, Elisha, Providence, Rhode Island (9).

## E.

Easton, Norman, Fall River, Massachusetts (14).
Eaton, Daniel C., New Haven, Connecticut (13).
Eliot, Charles W., Boston, Massachusetts (14).
Elliott, Ezekiel B., Boston, Massachusetts (10).
Elwyn, Alfred L., Philadelphia, Pennsylvania (1).
Emerson, George B., Boston, Massachusetts (1).
Engelmann, George, St. Louis, Missouri (1).
Engstrom, A. B., Burlington, New Jersey (1).
Eustis, Henry L., Cambridge, Massachusetts (2).
Evans, Charles W., Buffalo, New York (15).
*Everett, Edward, Boston, Massachusetts (2).
Everett, J. D. Winsor, Nova Scotia (14).
Ewing, Thomas, Lancaster, Ohio (5).

## F.

Fairbanks, Henry, Hanover, New Hampshire (14).
Farnham, Thomas, Buffalo, New York (15).
Ferrell, William, Nashville, Tennessee (11).
Ferris, Isaac, New York, New York (6).
Field, Roswell, Greenfield, Massachusetts (13).
Fillmore, Millard, Buffalo, New York (7).
Fisher, Mark, Trenton, New Jersey (10).
*Fitch, Alexander, Hartford, Connecticut (1).
Fitch, Edward H., Ashtabula, Ohio (11).
Fitch, O. H., Ashtabula, Ohio (7).
Forbush, E. B., Buffalo, New York (15).
Force, Peter, Washington, District of Columbia (4).
Fosgate, Blanchard, Auburn, New York (7).
Foster, J. W., Chicago, Illinois (1).
*Fox, Charles, Grosse Isle, Michigan (7).
Frothingham, Frederick, Buffalo, New York (11).

## G.

*Gay, Martin, Boston, Massachusetts (1).
Gay, C. C. F., Buffalo, New York (15).
Gibbes, L. R., Charleston, South Carolina (1).
Gibbon, J. H., Charlotte, North Carolina (3).
Gibbs, Wolcott, Cambridge, Massachusetts (1).
*Gillespie, W. M., Schenectady, New York (10).
Gillmore, Q. A., Jr., New York, New York (13).
Gilman, Daniel C., New Haven, Connecticut (10).
*Gilmor, Robert, Baltimore, Maryland (1).
Glynn, James, Geneva, New York (1).
Gold, Theodore S., West Cornwall, Connecticut (4).
Goodwin, William F., Richmond, Virginia (10).
*Gould, Augustus A., Boston, Massachusetts (11).
*Gould, B. A., Boston, Massachusetts (2).
Gould, B. A., Cambridge, Massachusetts (2).
*Graham, James D., Washington, District of Columbia (1).
Gray, Asa, Cambridge, Massachusetts (1).
*Gray, James H., Springfield, Massachusetts (6).
Green, Traill, Easton, Pennsylvania (1).
*Greene, Benjamin D., Boston, Massachusetts (1).
Greene, Samuel, Woonsocket, Rhode Island (9).
*Griffith, Robert E., Philadelphia, Pennsylvania (1).
Grinnan, A. G., Orange Court House, Virginia (7).
Grote, Augustus, R. Buffalo, New York (15).
Guyot, Arnold, Princeton, New Jersey (1).

## H.

*Hackley, Charles W., New York, New York (4).
Hadley, George, Buffalo, New York (6).
Haldeman, S. S., Columbia, Pennsylvania (1).
*Hale, Enoch, Boston, Massachusetts (1).
Hall, James, Albany, New York (1).
Hall, N. K., Buffalo, New York (7).
Hamlin, A. C., Bangor, Maine (10).
Hammond, George T., Newport, Rhode Island (14).
Hance, Ebenezer, Morrisville, Pennsylvania (7).
Hand, Thomas J., Baltimore, Maryland (12).
Hanover, M. D., Cincinnati, Ohio (13).

*Hare, Robert, Philadelphia, Pennsylvania (11).
*Harlan, Joseph G., Haverford, Pennsylvania (8).
*Harlan, Richard, Philadelphia, Pennsylvania (1).
Harman, Henry M., Baltimore, Maryland (12).
*Harris, Thaddeus W., Cambridge, Massachusetts (1).
Harrison, B. F., Wallingford, Connecticut (11).
*Hart, Simeon, Farmington, Connecticut (1).
Hartshorne, Henry, Philadelphia, Pennsylvania (12).
Harvey, Charles W., Buffalo, New York (15).
Harvey, Leon F., Buffalo, New York (15).
Haven, Samuel F., Worcester, Massachusetts (9).
*Hayden, H. H., Baltimore, Maryland (1).
Hayes, George E., Buffalo, New York (15).
*Hayward, James, Boston, Massachusetts (1).
Henry, Joseph, Washington, District of Columbia (1).
Herzen, W., Columbus, Ohio (15).
Hickok, M. J., Scranton, Pennsylvania (11).
Hickok, W. C., Burlington, Vermont (16).
Hilgard, Eugene W., Oxford, Mississippi (11).
Hilgard, Julius E., Washington, District of Columbia (4).
Hill, S. W., Hancock, Lake Superior (6).
Hill, Thomas, Cambridge, Massachusetts (3).
Hitchcock, Charles H., New York, New York (11).
*Hitchcock, Edward, Amherst, Massachusetts (1).
Hitchcock, Edward, Amherst, Massachusetts (4).
Hoadley, E. S., Springfield, Massachusetts (13).
Homes, Henry A., Albany, New York (11).
Horsford, E. N., Cambridge, Massachusetts (1).
*Horton, William, Craigville, Orange Co., New York (1).
Hough, Franklin B., Lowville, New York (4).
Hough, G. W., Albany, New York (15).
*Houghton, Douglas, Detroit, Michigan (1).
*Howland, Theodore, Buffalo, New York (15).
Howell, Robert, Nichols, New York (6).
Hubbard, Oliver P., Hanover, New Hampshire (1).
*Hunt, Freeman, New York, New York (11).
Hunt, George, Providence, Rhode Island (9).
*Hunt, E. B., Washington, District of Columbia (2).
Hunt, Thomas S., Montreal, Canada (1).

Hubbert, James, Richmond, Province of Quebec (16).
Hungerford, Edward, Burlington, Vermont (10).
Hyatt, James, Bangall, New York (10).

### I.

*Ives, Thomas P., Providence, Rhode Island (10).

### J.

Jackson, Charles T., Boston, Massachusetts (1).
Jenkins, Thornton A., Washington, District of Columbia (7).
Jillson, B. C., Nashville, Tennessee (14).
*Johnson, W. R., Washington, District of Columbia (1).
Johnston, John, Middletown, Connecticut (1).
*Jones Catesby Ap. R., Washington, District of Columbia (8).
Joy, C. A., New York, New York (8).
Judd, Orange, New York, New York (4).

### K.

Keely, G. W., Waterville, Maine (1).
Keep, N. C., Boston, Massachusetts (13).
Kerr, W. C., Davidson College, North Carolina (10).
Kimball, J. P., New York, New York (15).
King, Mary B. A., Rochester, New York (15).
Kirkwood, Daniel, Canonsburg, Pennsylvania (7).
Kite, Thomas, Cincinnati, Ohio (5).

### L.

Lapham, Increase A., Milwaukie, Wisconsin (3).
*Lasel, Edward, Williamstown, Massachusetts (1).
Lattimore, S. A., Lima, New York (15).
Lauderdale, John V., Geneseo, New York (10).
Lawrence, George N., New York, New York (7).
Lea, Isaac, Philadelphia, Pennsylvania (1).
Le Conte, John L., Philadelphia, Pennsylvania (1).
Le Conte, John, Columbia, South Carolina (3).
Le Conte, Dr. Joseph, Columbia, South Carolina (3).
*Lederer, Baron von, Washington, District of Columbia (1).

Lee, John R., Buffalo, New York (15).
Leonard, A. M., Lockport, New York (15).
Lesley, J. P., Philadelphia, Pennsylvania (2).
Lesley, Joseph, Jr., Philadelphia, Pennsylvania (8).
Letchworth, William P., Portage, New York (15).
*Lieber, Oscar M., Columbia, South Carolina (8).
*Lincklaen, Ledyard, Cazenovia, New York (1).
Lindsley, J. B., Nashville, Tennessee (1).
*Linsley, James H., Stafford, Connecticut (1).
Little, George, Oakland, Mississippi (15).
Litton, A., St. Louis, Missouri (12).
Locke, Joseph M., Cincinnati, Ohio (13).
Locke, Luther F., Nashua, New Hampshire (7).
Logan, William E., Montreal, Canada (1).
Loomis, Elias, New Haven, Connecticut (1).
Loomis, L. C., Wheeling, West Virginia (9).
Loomis, Silas L., Washington, District of Columbia (7).
Loosey, Charles F., New York, New York (12).
Lord, John, Stamford, Connecticut (13).
Lovering, Joseph, Cambridge, Massachusetts (2).
Lothrop, Joshua R., Buffalo, New York (15).
Lunn, William, Montreal, Canada (11).
Lyman, Chester S., New Haven, Connecticut (4).
Lyman, B. S., Philadelphia, Pennsylvania (15).
Lyman, Henry, Montreal, Canada (11).
Lynch, P. N., Charleston, S. C. (2).

## M.

Marissal, F. V., Fall River, Massachusetts (14).
Marsh, O. C., New Haven, Connecticut (15).
Marshall, Charles D., Buffalo, New York (15).
Marshall, Orasmus H., Buffalo, New York (15).
M'Conihe, Isaac, Troy, New York (4).
McRae, John, Camden, South Carolina (3).
Mahan, D. H., West Point, New York (9).
Marcy, Oliver, Evanston, Illinois (10).
*Marsh, Dexter, Greenfield, Massachusetts (1).
*Mather, William W., Columbus, Ohio (1).

Mauran, J., Providence, Rhode Island (2).
Mayhew, D. P., Ypsilanti, Michigan (13).
Maynard, Alleyne, Cleveland, Ohio (7).
Meade, George G., Philadelphia, Pennsylvania (15).
Means A., Oxford, Georgia (5).
Meek, F. B., Washington, District of Columbia (6).
Meigs, James A., Philadelphia, Pennsylvania (12).
Miles, Henry H., Lenoxville, Canada East (11).
Miller, Samuel, New Haven, Connecticut (14).
Minifie, William, Baltimore, Maryland (12).
Mitchell, Maria, Poughkeepsie, New York (4).
Morgan, DeWitt C., Baltimore, Maryland (14).
Morgan, Lewis H., Rochester, New York (10).
Morris, D., Ellingham, Connecticut (14).
Morris, J. R., Houston, Texas (11).
Morris, John G., Baltimore, Maryland (12).
*Morton, S. G., Philadelphia, Pennsylvania (1).
Munroe, Nathan, Bradford, Massachusetts (6).
Murray, David, New Brunswick, New Jersey (11).

## N.

Nason, Henry B., Beloit, Wisconsin (13).
Nelson, Cleland K., Annapolis, Maryland (12).
Newberry, J. S., New York, New York (5).
Newcomb, Simon, Washington, District of Columbia (13).
*Newton E. H., Cambridge, New York (1).
Newton, Hubert A., New Haven, Connecticut (6).
Newton, Robert S., New York, New York (15).
*Nicollett, J. N., Washington, District of Columbia (1).
Niles, W. H., Cambridge, Massachusetts (16).
*Norton, J. P., New Haven, Connecticut (1).
Norton, W. A., New Haven, Connecticut (6).
Nye, A. H., Buffalo, New York (15).

## O.

*Oakes, William, Ipswich, Massachusetts (1).
Oliver, James Edward, Lynn, Massachusetts (7).
*Olmsted, Alexander F., New Haven, Connecticut (4).

*OletmDds, enison, New Haven, Connecticut (1).
*Olmsted, Denison, Jr., New Haven, Connecticut (1).
Ordway, John M., Providence, Rhode Island (9).

## P.

Packard, A. S. Jr., Salem, Massachusetts (16).
Paine, Cyrus F., Rochester, New York (12).
Painter, Minshall, Lima, Pennsylvania (7).
Palmer, Everard, Buffalo, NewYork (15).
Parker, Henry E., Hanover, New Hampshire (11).
*Parkman, Samuel, Boston, Massachusetts (1).
Parmelee, Dubois D., New York, New York (15).
Parvin, Theodore S., Iowa City, Iowa (7).
Pease, Francis S., Buffalo, New York (15).
Peck, Edward W., Burlington, Vermont (16).
Peck, William G., New York, New York (13).
Peirce, Benjamin, Cambridge, Massachusetts (1).
Peirce, James M., Cambridge, Massachusetts (11).
Perkins, George R., Utica, New York (1).
Perkins, Maurice, Schenectady, New York (15).
Perry, John B., Brookline, Massachusetts (16).
*Perry, M. C., New York, New York (10).
Phelps, Almira L., Baltimore, Maryland (13).
Phelps, Charles E., Baltimore, Maryland (13).
Pierce, Henry M., New York, New York (15).
Pierrepont, H. E., Brooklyn, New York (14).
Plant, I. C., Macon, Georgia (3).
*Plumb, Ovid, Salisbury, Connecticut (9).
Poole, Henry W., Boston, Massachusetts (14).
Pope, Charles A., St. Louis, Missouri (12).
*Porter, John A., New Haven, Connecticut (14).
Powell, Samuel, Philadelphia, Pennsylvania (13).
Prescott, William, Concord, New Hampshire (1).
Pruyn, J. V. L., Albany, New York (1).
Pugh, Evan, Centre Co., Pennsylvania (14).
Putnam, F. W., Salem, Massachusetts (10).

## Q.

Quincy, Edmund, Jr., Dedham, Massachusetts (11).

## R.

Rankin, Alexander T., Buffalo, New York (15).
Ranney, Orville W., Buffalo, New York (15).
Rauch, J. H., Chicago, Illinois (11).
Raymond, R. W., New York, New York (15).
Redfield, John H., Philadelphia, Pennsylvania (1)
*Redfield, William C., New York, New York (1).
Rice, Clinton, New York, New York (7).
Richardson, Horace, Boston, Massachusetts (12).
Ritchie, E. S., Boston, Massachusetts (10).
Robertson, Thomas D., Rockford, Illinois (10).
Robinson, Coleman T., Buffalo, New York (15).
Rochester, Thomas F., Buffalo, New York (15).
Rockwell, Alfred P., New Haven, Connecticut (10).
*Rockwell, John A., Norwich, Connecticut (10).
Rodman, William M., Providence, Rhode Island (9).
Rogers, Fairman, Philadelphia, Pennsylvania (11).
*Rogers, James B., Philadelphia, Pennsylvania (1).
Rogers, W. A., Alfred, New York (15).
Rogers, W. B., Boston, Massachusetts (1).
Rood, O. N., New York, New York (14).
Roosevelt, Clinton, New York, New York (11).
Rumsey, Bronson C., Buffalo, New York (15).
Rumsey, Dexter P., Buffalo, New York (15).
Russell, Andrew, Ottawa, Canada West (11).
Rutherford, Louis M., New York, New York (13).

## S.

Safford, J. M., Nashville, Tennessee (6).
Safford, Truman H., Chicago, Illinois (13).
Sanborn, Francis G., Andover, Massachusetts (13).
Sargent, Rufus, Auburn, New York (10).
Scarborough, George, Sumner, Kansas (2).
Schanck, J. Stillwell, Princeton, New Jersey (4).

Schofield, J. M., Washington, District of Columbia (13).
Schott, Arthur C. V., Georgetown, District of Columbia (8).
Schott, Charles A., Washington, District of Columbia (8).
Scudder, Samuel H., Cambridge, Massachusetts (13).
Sellstedt, Laurentius G., Buffalo, New York (15).
Seward, William H., Auburn, New York (1).
Sexton, Jason, Buffalo, New York (15).
Seymour, M. H., Montreal, Canada (11).
Shaefer, P. W., Pottsville, Pennsylvania (4).
Sherwood, Albert, Buffalo, New York (15).
Sias, Solomon, Charlotteville, New York (10).
Sill, Elisha N., Cuyahoga Falls, Ohio (6).
*Silliman, Benjamin, New Haven, Connecticut (1).
Silliman, Benjamin, New Haven, Connecticut (1).
Sillsbee, E. A., Salem, Massachusetts (14).
Skinner, John B., Buffalo, New York (15).
Smith, A. D., Providence, Rhode Island (14).
*Smith, J. V., Cincinnati, Ohio (5).
Smith, James Y., Providence, Rhode Island (9).
*Smith, Lyndon A., Newark, New Jersey (9).
Snell, Eben S., Amherst, Massachusetts (2).
*Sparks, Jared, Cambridge, Massachusetts (2).
Spencer, Charles A., Buffalo, New York (14).
Spring, Charles H., Boston, Massachusetts (13).
Squier, George L., Buffalo, New York (15).
Stanard, Benjamin A., Cleveland, Ohio (6).
Stearns, Josiah A., Boston, Massachusetts (10).
Stearns, William F., Oxford, Mississippi (13).
Steele, Oliver G., Buffalo, New York (15).
Steiner, Lewis H., Frederick City, Maryland (7).
Stevenson, Charles L., Charlestown, Massachusetts (14).
Stewart, William W., Buffalo, New York (15).
Stimpson, William, Chicago, Illinois (12).
Stoddard, O. N., Oxford, Ohio (7).
Stone, Edwin M., Providence, Rhode Island (9).
Storer, D. H., Boston, Massachusetts (1).
Storer, Frank H., Boston, Massachusetts (13).
Sullivant, W. S., Columbus, Ohio (7).
Swallow, G. C., Columbia, Missouri (10).
Swinburne, John, Albany, New York (6).

## T.

*Tallmadge, James, New York, New York (1).
*Taylor, Richard C., Philadelphia, Pennsylvania (1).
*Teschemacher, J. E., Boston, Massachusetts (1).
Thomas, Calvin F. S., Buffalo, New York (15).
Thompson, Alexander, Aurora, New York (6).
Thompson, Aaron R., New York, New York (1).
*Thompson, Z., Burlington, Vermont (1).
*Thurber, Isaac, Providence, Rhode Island (9).
Tillman, S. D., New York, New York (15).
Tingley, J., Meadville, Pennsylvania (15).
Tingley, Joseph, Greencastle, Indiana (14).
Tolles, Robert B., Boston, Massachusetts (15).
Torrey, John, New York, New York (1).
*Totten, J. G., Washington, District of Columbia (1).
Townsend, Franklin, Albany, New York (4).
*Townsend, John K., Philadelphia, Pennsylvania (1).
*Troost, Gerard, Nashville, Tennessee (1).
Trowbridge, W. P., New York, New York (10).
*Tuomey, M., Tuscaloosa, Alabama (1).
Turner, Henry E., Newport, Rhode Island (14).
*Tyler, Edward R., New Haven, Connecticut (1).
Tyler, P. B., Springfield, Massachusetts (13).
Tyson, Philip T., Baltimore, Maryland (12).

## U.

Upham, G. B., Boston, Massachusetts (14).

## V.

*Vancleve, John W., Dayton, Ohio (1).
Van Pelt, William, Williamsville, New York (7).
*Vanuxem, Lardner, Bristol, Pennsylvania (1).
Vaux, William S., Philadelphia, Pennsylvania (1).
Verrell, A. E., New Haven, Connecticut (16).
Viele, Henry K., Buffalo, New York (15).
Vose, George L., Paris Hill, Maine (15).
Vought, John H., Buffalo, New York (15).

## W.

*Wadsworth, James S., Genesee, New York (2).
Wagner, Tobias, Philadelphia, Pennsylvania (9).
Walker, Joseph, Oxford, New York (10).
Wales, Torrey E., Burlington, Vermont (16).
Wales, William, Fort Lee, New York (15).
Walker, Joseph, Oxford, New York (10).
*Walker, Sears C., Washington, District of Columbia (1).
*Walker, Timothy, Cincinnati, Ohio (4).
Ward, Henry A., Rochester, New York (13).
Warner, H. G., Rochester, New York (11).
Warren, G. K., Washington, District of Columbia (12).
*Warren, John C., Boston, Massachusetts (1).
*Webster, H. B., Albany, New York (1).
*Webster, J. W., Cambridge, Massachusetts (1).
*Webster, M. H., Albany, New York (1).
Webster, Nathan B., Kenansville, North Carolina (7).
Wenz, J., New Orleans, Louisiana (15).
West Charles E., Brooklyn, New York (1).
Wheatland, Henry, Salem, Massachusetts (1).
*Wheatland, Richard H., Salem, Massachusetts (13).
Wheatley, Charles M., Phœnixville, Pennsylvania (1).
Wheeler, T. B., Montreal, Canada (11).
Wheildon, W. W., Charlestown, Massachusetts (13).
White, Henry H., Harrodsburg, Kentucky (14).
Whitney, Asa, Philadelphia, Pennsylvania (1).
Whitney, H. H., Montreal, Canada (11).
Whitney, J. D., Northampton, Massachusetts (1).
Whitney, William D., New Haven, Connecticut (12).
Whittlesey, Charles, Cleveland, Ohio (1).
Willard, Emma, Troy, New York (15).
Williams, Henry W., Boston, Massachusetts (11).
Williams, Matthew, Syracuse, New York (13).
Williamson, R. S., San Francisco, California (12).
Willmarth, A. F., New York, New York (15).
Wilson, Daniel, Toronto, Canada (10).
Winchell, Alexander, Ann Arbor, Michigan (3).
*Woodbury, L., Portsmouth, New Hampshire (1).

Worthen, A. H., Springfield, Illinois (5).
Wright, A. W., New Haven, Connecticut (14).
Wright, Chauncey, Cambridge, Massachusetts (9).
*Wright, John, Troy, New York (1).
Wurtele, Louis C., Lennoxville, Canada East (11).
Wurtz, Henry, New York, New York (10).
Wyckoff, C. C., Buffalo, New York (15).

## Y.

Youmans, E. L., Saratoga Springs, New York (6).
*Young, Ira, Hanover, New Hampshire (7).

The above list contains five hundred and twenty names, of which one hundred and five are of deceased members.

# MEMBERS ELECTED

AT

# THE BURLINGTON MEETING.[*]

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†Abbe, Cleveland, Washington, District of Columbia.
Adams, J. S., Burlington, Vermont.
Allen, Joseph D., Burlington, Vermont.
*Angell, James B., Burlington, Vermont.
Barnes, Lawrence, Burlington, Vermont.
Benedict, G. G., Burlington, Vermont.
*Benedict, G. W., Burlington, Vermont.
*Bigelow, George H., Burlington, Vermont.
Buckham, M. H., Burlington, Vermont.
Burton, O. A., Burlington, Vermont.
Cannon, L. G. B., Burlington, Vermont.
Carpenter, Walter, Burlington, Vermont.
Catlin, Albert L., Burlington, Vermont.
Catlin, H. W., Burlington, Vermont.

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[*] Those marked with an asterisk have paid the assessment and signed the constitution; those marked thus (†) have paid the assessment; those marked thus(‡) have declined; the others have not responded.

Davis, Mial, Burlington, Vermont.
Day, S. F., Ballston, New York.
*Delano, B. L., Boston, Massachusetts.
‡Dodge, O. A., Burlington, Vermont.
Edmands, George F., Burlington, Vermont.
Englesby, L. B., Burlington, Vermont.
Hickok, Henry P., Burlington, Vermont.
Hickok, James W., Burlington, Vermont.
*Hickok, William C., Burlington, Vermont.
Hopkins, Theodore A., Burlington, Vermont.
Howard, D. D., Burlington, Vermont.
*Hubbert, James, Richmond, Province of Quebec.
Huntington, Samuel, Burlington, Vermont.
Lewis, James, Burlington, Vermont.
Linsley, D. C., Burlington, Vermont.
Loomis, Henry, Burlington, Vermont.
Marsh, L., Burlington, Vermont.
*Niles, W. H., Cambridge, Massachusetts.
Noyes, Carolus, Burlington, Vermont.
*Packard, A. S., Jr., Salem, Massachusetts.
‡Parsons, W. L., Le Roy, New York.
*Peck, Edward W., Burlington, Vermont.
†Perry, John B., Brookline, Massachusetts.
Pierce, J. S., Burlington, Vermont.
Pomeroy, J. N., Burlington, Vermont.
Roberts, Daniel, Burlington, Vermont.
Shaw, William G., Burlington, Vermont.
Shedd, James A., Burlington, Vermont.
Underwood, Levi, Burlington, Vermont,
Van Duzee, Mary K., Buffalo, New York.
Vansiclew, F. M., Burlington, Vermont.
*Verrell, A. E., New Haven, Connecticut.
*Wales, Torrey E., Burlington, Vermont.
Walling, H. F., New York, New York.
‡Worcester, J. H., Burlington, Vermont.

# ADDRESS

OF

# PROFESSOR J. S. NEWBERRY,

## PRESIDENT OF THE AMERICAN ASSOCIATION FOR THE YEAR 1867,

### ON RETIRING FROM THE DUTIES OF PRESIDENT.

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GENTLEMEN OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE:—

EVERY day of our lives we hear that this is an age of *progress;* and that it is so we find evidence at every turn. The rapidity with which effects follow causes in human events, the celerity with which the plan is carried into execution, gives to a *year*, in the experience of one of the present generation, the practical value of a lifetime in ages past. Much labor has been expended on the exposition of the causes of the mental activity of the present age, and of the grand achievements which have attended it; and yet the key to the whole enigma is to be found in the universal adoption of the comparatively new system of inductive reasoning. It would be foreign to my purpose to attempt to illustrate or defend this proposition, and I must, therefore, trust to its acceptance without argument, while we pass to consider that branch of the subject which more immediately demands our attention.

Although the progress of the age to which I have referred has been a matter of wonder and delight to all students of humanity and civilization, many of our best men have been somewhat alarmed and dizzied by it; and, while accepting the achievements of modern industry and thought as full of present good and future promise, they are not a little concerned lest our railroad speed of progress should lead to its legitimate consequences, a final crash—not of things material, but of those of infinitely more value — of opinions and of faith. As often as it is boasted that this is pre-eminently an age of progress, that boast is met by the inevitable "but" (which qualifies our praise of all things earthly) "it is equally an age of scepticism." For the truth of this assertion the proof is nearly as palpable as of the other; and in view of the ruthlessness with which the man of the present removes ancient landmarks and profanes shrines hallowed by the faith of centuries, it is not surprising that many of the good and wise among us should deplore a liberty of thought leading, in their view, inevitably to license, and mourn over this wide-spread scepticism as an evil and inscrutable disease that has fallen upon the minds and hearts of men.

Now for every consequence there must be an adequate cause; and while confessing the fact of this modern lack of faith, I have thought that a few moments given to an analysis of it, and an attempt to trace it to its source, might not be wholly misspent, — might possibly, indeed, result in giving a grain of encouragement to those who look with distrust and dread upon the investigations and discussions which now occupy so large a portion of the time and thought of our men of science.

If the wheels of time could, for our benefit, be rolled back, and we could see in all its details the civilization of Europe three or four hundred years ago, we should find that our so much respected ancestors, who fill so large a space on the page of history, were little better than barbarians. Among the English, the French, the Germans, Spanish, and Italians we should find a phase of civilization which, excepting that it included the elements — as yet but imperfectly developed — of a true religious faith, is scarcely to be preferred to that of the Chinese. Aside from the vast difference perceptible between the civilization of that epoch and ours, as exhibited in the political condition of the people, in their social economy and morals, the general intellectual darkness of the period referred to could not fail to impress us both profoundly and painfully. Out of that darkness and chaos have come, as if by magic, all our modern democracy, with its individual liberty and dignity, all our civil and religious freedom, all our philanthropy and benevolence, all our diffused comfort and luxury, most of our good manners and good morals, and all the splendid achievements of our modern scientific investigation.

It is unnecessary for me here to describe in detail the origin and growth of modern science. That has been so well done by Dr. Whewell, that all men of education are familiar with the steps by which the grand, beautiful, and symmetrical fabric formed by the grouping of the natural sciences has acquired its present lofty proportions.

Previous to the period when the Baconian philosophy was accepted as a guide in scientific investigation, but one department of science had attained a development which has any considerable claim to our respect. Mathematics, both pure and applied, had been assiduously cultivated from the remotest antiquity, and with a degree of success which has left to modern investigators little more than the elaboration of the thoughts of their predecessors. In Metaphysics, — which had claimed even a larger share of the attention of the scholars of antiquity, — little progress had been made. Perhaps I am justified in saying little progress was possible, inasmuch as in the light of all the great material discoveries of modern times the metaphysicians of the present day are debating, with as little harmony of opinion, the same questions that divided the rival schools of the Greeks. Each successive generation has had its two parties of idealists and realists, who have discussed the intangible problems which absorbed the great minds of Plato and Aristotle with a degree of enthusiasm and energy — and it may be of acrimony — which seems hardly compensated by any expansion of the human intellect or amelioration of the condition of mankind.

Of the *physical sciences* we may say that, except Astronomy, no one had an existence prior to the time of Bacon. There were men of vast learning, and much that was *called* science in the mass of reported observation that had been accumulating from century to century, until it had become "*rudis indigestaque moles;*" but in this — though it constituted the pride of universities, the intellectual capital with which the savant thought himself rich, and that on which the professional man depended for success — there was far more error than truth, and its study was sure to mislead and likely to injure. In these circumstances the task before the scientific reformer was one more difficult than that of clearing the Augean stables; no less, in fact, than to seat himself before this great heap of rubbish, this mass of truth and error, — of the sublimest philosophy with the wildest fiction, — to patiently winnow out the grains of truth, and from infinitesimal facts build up a fabric that should have a sure foundation below, and beauty and symmetry above. What more natural, then, than that the process adopted in winnowing this chaff-heap should be that which had given success to the only true science of the period? — that the mathematical touchstone should be the test by which every grain was tried? And such precisely was the course pursued; perhaps we may even say the only one practicable. Provided with this test, the reformer was compelled to rejudge upon its merits every proposition submitted to him, and accepted only as true such as could be demonstrated. The materials which composed the science to be reformed naturally fell into several categories. First, — That which had been *demonstrated* to be true. Second, — That which was *demonstrable.* Third, — That which was *probable.* Fourth, — That which was *possible,* and Fifth, — That which was *impossible.* Of these he systematically rejected all but the first and second classes. And this, in few words, has been the method adopted, not only in the purification of old science, but in the creation of new.

It will be seen at a glance, that in this process, all that was contrary to the order of nature (supernatural or spiritual) was necessarily excluded; and it was taken for granted that the mathematical or logical faculty of the human mind was capable of solving *all* the problems of the material universe. Sir William Hamilton and others have demonstrated the inadequacy of mathematical processes as a guide to human reason, and a moment's thought will show us that our boasted intellect is incapable of grasping even all the material truths which are plainly presented to it. To illustrate: as we scan the heavens of a clear evening, we recognize the fact that we stand, as it were, on a point in space, where our field of vision is limitless; the heavenly bodies stretching away into the realms of obscurity, and becoming invisible only through the imperfection of our organs of vision. Bringing to our aid the most powerful telescopes, we are apparently as far as ever from reaching the limits of the universe; and when we endeavor to *conceive* of such a limit, the reasoning faculty finds itself incapable of grasping either of the two alternatives offered to it, one or the other of which must be true. The universe must be either limited or limitless. But no man can conceive of a universe without a limit; and if it be regarded as terminated by definite boundaries, the imagination strives in vain to fill the void which reaches beyond. In fact, we stand here face to face with infinity, and recognize the fact that the infinite exists without the power to comprehend it.

The same is true of time. We cannot conceive of its beginning or its end. All things which come within the scope of our senses are limited in duration and circumscribed in space; and though we prate flippantly of the infinite, the pretence that we can grasp it is simply idle talk.

Conducted on such a plan, it was inevitable that scientific investigations should be narrow and materialistic in their tendency. No matter how strong the probability in favor of the truth of a certain proposition, — though the whole fabric of society were based upon its acceptance, and it formed the foundation of civil and moral laws; even though it controlled the actions of the philosopher himself, — if not proved consistent with nature's physical and material laws it must be rejected as unworthy to enter into the construction of the edifice he was erecting. In his great task of undoing the work of blind, unreasoning faith, and wild, illogical speculation, all the fruit of such faith or speculation must be looked upon as matter valueless to his hand. We may even go further and say that were it true that the Supreme Intelligence *had* created the material universe, and by special providence modified or thwarted the general laws through which that universe was governed, such divine supervision and such miraculous interposition must necessarily have been ignored.

Let it not be inferred, however, that each and all of the great men who have been engaged in this work of scientific reformation were necessarily driven to be impious iconoclasts, or that, in their efforts to emancipate themselves from time-honored errors, they necessarily prostituted the liberty they gained to selfish or sensual purposes. On the contrary, the most important advances which the human intellect has made within these later centuries have been due to the efforts of men of the purest and most conscientious character, — men whose lives were devoted with the utmost singleness of purpose to determine *what is truth*, — men who, knowing that all truth must be consistent with all other truth, were willing to go whithersoever it should lead. If it shall prove that they have been occupied with "mint, anise, and cumin," omitting the "weightier matters of the law," it is also true that in no other way could the material laws of the universe be thoroughly investigated than by making them the subjects of an absorbed and undivided attention. It would be as just to impugn the motives and decry the merits of the maker of our almanacs, because his mathematical calculations were not interlarded with moral maxims, as to reproach the student of natural phenomena because he did his work so well, and left to others the co-ordination of the results of his efforts with the accepted dogmas of religious faith.

And it is not true, in any sense, that these devotees of science have lived in vain; for to them we mainly owe the fact that man is not only wiser now than formerly, but that he is better and happier.

In justice to the man of science we must claim for him the position of co-laborer with, and indispensable ally to, the philanthropists and moralists; for from no source have they drawn richer lessons, stronger arguments, or more eloquent illustrations than from his discoveries.

And yet, while conceding conscientiousness and purity of motive to the vast majority of our men of science, and acknowledging the contributions they have made, and are making to human happiness; compelled by my sense of justice to defend their spirit, approve their methods, admire their devotion, and assert their usefulness, I cannot deny that the tendency of modern investigation is decidedly materialistic. All natural phenomena being ascribed to material and tangible causes, the search for and analysis of these causes have begotten a restless activity and an indomitable energy which will leave no stone unturned for the attainment of their object. But while this is apparent, and, indeed, inevitable, as has been seen from the sketch of the growth of modern science, I am far from sharing the alarm which it excites in the minds of many good men. Nor would I encourage or excuse that spirit of conservatism — to call it by no harsher term — which, for the safety of a popular creed, would, by any and all means, repress, and, if possible, arrest investigations that may, it is feared, become revolutionary and dangerous.

Such opposition, in the first place, must be fruitless. All history has proved that persecution by physical coercion or obloquy is powerless to arrest the progress of ideas, or quench the enthusiasm of the devotees of a cause approved by their moral sense. The problems before our men of science *must* be solved in the manner proposed, if human wisdom will suffice for the task. In every department of science are men actuated simply by a thirst for truth, whom neither heat nor cold, privation nor opposition, will hold back from their self-appointed tasks. We may, therefore, accept it as a finality, that this problem will be carried to its logical conclusion.

In the second place, if possible, the arrest of scientific investigation would be not only undesirable, but an infinite calamity to our race. As has been so often said, truth is consistent with itself. If, therefore, our faith in this or that is based on truth, we have no cause for fear that this truth will be proved untrue by other truths. And more than this: it seems to me that, in the reach and thoroughness of this material investigation, we may hope for such demonstration of the reality of things immaterial as shall produce a deeper and more universal *faith* than has ever yet prevailed.

Through this very spirit of scepticism which pervades the modern sciences we are compelled to exhaust all material means before we can have recourse to the supernatural. When, however, that is done, and men have tried patiently and laboriously, but in vain, to refer all natural phenomena to material causes, *then*, having proved a negative, they will be compelled to accept the existence of truth not reached by their touchstone, and faith be recognized as the highest and best knowledge.

That such will be the result is the confident expectation of many of the wisest of the scientific men whose influence is looked upon with such alarm by those who, in their anxiety for their faith, demonstrate its weakness.

Already, as it seems to me, scientists have reached the wall of adamant — the *inscrutable* — that surrounds them on every side, and, ere long, we may expect to see them return to that heap of chaff from which the germs of modern science were winnowed, with the conviction that there were left buried there other germs of other and higher truths than those they gleaned, — truths without which human knowledge must be a dwarfed and deformed thing.

A few illustrations from the many that might be cited will suffice to show the materialistic tendency of modern science. In "Pure Philosophy," — as the students of Psychology are fond of styling their science, — the names alone of Comte, Buckle, Herbert Spencer, Mill, and Draper will suggest the more prominent characters of the school they may be said to represent. The most conspicuous feature in the "Positive Philosophy" of Comte is the effort it exhibits to co-ordinate the laws of mind with those of matter. Spencer is a thorough-going mental Darwinist, who considers the highest attributes of the human mind, the loftiest aspirations of the soul, as only developed instincts, as these were but developed sensations. Mill, more guarded, more fully inspired with the spirit of the age, — which *believes* nothing, and is a foe to speculation, — leaves the *history* of our faculties to be written, if at all, by others; takes them as they are, but reasons of conscience and free-will with an independence of popular belief that savors more of the material than the spiritual school. Buckle wore himself out in a vain chase after an *ignis fatuus*, an inherent, inflexible law of human progress, and hence of human history. Draper is a developmentist, but not a Darwinian. With him civilization is a definite stage in the growth of mind; a degree of development to which it is impelled by a *vis a* *tergo*, not unlike, in kind, to that which evolves from the germ, the bud, the leaf, the flower, and the fruit in plant-life, — a development which, when unchecked and free, will be regular and inevitable, but which is so modified by the accidents of race, climate, soil, geographical position, etc., as to render it difficult to say whether the rule or the exception has, in his judgment, greatest potency. If he were a consistent Darwinist, the accidents of development would be its law.

Among the students of "Social Science," — a new and important member of the sisterhoood of sciences, — as in most of the other departments of modern investigation, two groups of devotees are found; one patiently and conscientiously studying the problems of social organization, inspired with the true spirit of the Baconian Philosophy, ready to follow whithersoever the facts shall lead, and having for their object that noblest of all objects, the increase of human happiness. The other class of investigators, in whom the bump of destructiveness is largely developed, would be delighted to tear down the whole fabric of society, and abrogate all laws, both human and divine. Looking upon man as literally the creature of circumstances, as an inert atom driven about by material forces, conscience and responsibility are by them repudiated, and laws and penalties regarded simply as relics of barbaric despotism. The dreary soul-killing creed of these fatalists is fortunately so repugnant to the reason and feelings of the majority of men, that there is little danger that their efforts will reach their legitimate conclusion in throwing society into a state of anarchy and chaos.

In Theology or Biblical Science, the tendency of modern investigation is so distinctly felt, that I need only refer to it. The spirit of independent criticism, so noticeable elsewhere, is still more conspicuous here; assuming sometimes the form of derisive scepticism, but oftener of cold, passionless judgment on the reported facts of sacred history, or the psychological phenomena of religious faith, studied simply as scientific problems.

The names of Strauss, Renan, and Colenso will suggest the results to which men, possibly honest, are led by this so-styled "enlightened and emancipated spirit of inquiry;" while "Ecce Homo" and cognate productions may be considered as the fruit of this spirit, tempered by a very liberal but apparently sincere faith.

Aside from these more marked examples of the decided "set" in the tide of modern religious opinions, we everywhere see evidences that no part of the religious world is unmoved by it. In every sect and section an impulse is felt to substitute for abstract faith, the "faith without works," — rather a characteristic of the religion of our fathers, and not unknown at present, — that other faith which is evidenced *by* works. In other words: in our day more and more value is being attached to *this life*, as a sphere for religious effort and experience. With what propriety, I leave to the individual judgment of my auditors; the faith of every sect and man is coming to be respected and valued precisely in the ratio of the purity, unselfishness, and active sympathy in the life produced by it.

While, therefore, we have less now than formerly of the self-centred and fruitless piety of the old deacon, who excused his avarice by proclaiming that "business was one thing and religion another, and he never allowed them to interfere," in place of that we have many an Abou Ben Adhem, and all the splendid exhibitions of modern philanthropy.

Though the golden mean displayed in the life and words of Christ is far better than either extreme, I cannot but think the present religious condition of the world is better than any which has preceded it.

In Ethnology, — the pre-historic history of the human race, — the researches of a large number of investigators who are devoted to its study have made interesting and important additions to our knowledge; but it cannot be denied that the result of such investigation has been to create general distrust of our previously accepted chronology, and give an antiquity to man such as the scholars of a previous generation would have looked upon as not only unwarranted but impious. It should be said, however, that our preconceived opinions of the antiquity of the human race — like those of the age of the earth itself — were based upon no solid foundation in nature, history, or revelation; and that our system of chronology was a matter of convention, about which there has been a wide latitude of opinion among the scholars of all ages.

In regard to the *origin* of man, — whether by special creation or by development, — we may confidently assert that modern investigation has given us no new light. Among those who have accepted the theory of a special creation, and have differed only in regard to the number of species and their places of origin or centres of creation, there has been such a diversity of opinion that all confidence in the reality and value of the bases of their reasoning has been lost.

Among the advocates of a multiplicity of species and diversity of origin we have from Blumenbach to Agassiz almost every number between fifteen and three as that of distinct species of the human race, scarcely any two writers advocating the same number. We may, therefore, very fairly infer that the facts upon which their conclusions are founded are not of a very clear and unmistakable character.

The subject of the origin of the human race brings us into the domain of zoölogy, and opens the wide question of the origin of species, which, of late years, has been shaking the moral and intellectual world as by an earthquake. While the various writers upon the origin of the human race were gathering with so much industry, and reporting with so much eloquence the proofs of a diversity of origin, the Darwinian hypothesis comes in and refers, not only all the human family, but all classes of animals and plants, to an initial point in a nucleated cell.

It would be impossible for any one to discuss in a fair and intelligent manner the great question of the origin of species, in anything less than a bulky volume. The merest mention is, therefore, all we can give to it at the present time. Although the appearance of Darwin's book on the Origin of Species communicated a distinct shock to the prevalent creeds, both religious and scientific, the hypothesis which it suggests, though now for the first time distinctly formularized, was by no means new; as it enters largely into the less clearly stated development theories of Oken, Lamarck, De Maillet, and the author of the "Vestiges of Creation." There was this difference, however, that in the developmental theories of the older writers the element of *evolution* had a place; the process of development had its main-spring in an inherent growth, or tendency, such as produces the evolution of the successive parts in plant-life, while, according to Darwin, the beautiful symmetry and adaptation which we see in nature is simply the form assumed by plastic matter in the mould of external circumstances.

Although this Darwinian hypothesis is looked upon by many as striking at the root of all vital faith, and is the *bête noire* of all those who deplore and condemn the materialistic tendency of modern science, still the purity of life of the author of the "Origin of Species," his enthusiastic devotion to the study of truth, the industry and acumen which have marked his researches, the candor and caution with which his suggestions have been made, all combine to render the obloquy and scorn with which they have been received in many quarters peculiarly unjust and in bad taste. It should also be said of Mr. Darwin that his views on the origin of species are not inconsistent with his own acceptance of the doctrine of Revelation; and that many of our best men of science look upon his theory as not incompatible with the religious faith which is the guide of their lives, and their hope for the future. To these men it seems presumption that any mere man should restrict the Deity in His manner of vitalizing and beautifying the earth. To them it is a proof of higher wisdom and greater power in the Creator that He should endow the vital principle with such potency that, pervaded by it, all the economy of nature, in both the animal and vegetable worlds, should be so nicely self-adjusting that, like a perfect machine from the hands of a master maker, it requires no constant tinkering to preserve the constancy and regularity of its movements.

This much I have said in view of the possible acceptance of the Darwinian theory by the scientific world. I should have stated *in limine*, however, that the Darwinian hypothesis is not, and can never be fully accepted by the student of science who is inspired with the spirit of the age. From the nature of things it can be proved only to a certain point, and while we accept that which is, or can be, proven, — and for it sincerely thank Mr. Darwin, — that which is hypothesis, or based only upon probabilities, we reject, as belonging in the category of mere theories, to disprove or purify which the modern scientific reform was inaugurated. Much, too, may be said against the sufficiency of "natural selection in the struggle of life," from observations made upon the phenomena of the economy of nature. Necessarily, the action of the Darwinian principle must be limited to the individual, be literally and purely selfish; and if it can be proved that a broader influence pervades the created world, that something akin to benevolence enters into the organization of the individual, — something which benefits others and not himself, — one single fact establishing this truth would hurl the entire Darwinian fabric to the ground, or rather restrict it to its proper bearing upon the limits of variation, and the mooted question of "what is a species?"

One of the most potent influences in the perpetuation of species is fecundity in the individual, whereas we see in social insects the economy of the community is best served by a total loss of this power in the great majority of the individuals which compose it. This objection will perhaps be met by the Darwinians with the assertion that the community, in fact, constitutes an individual; but I must confess that I find it difficult to comprehend how the sterility of the workers in ants and bees was ever introduced through the medium of modified descent, the Darwinian method, or how it is kept up from generation to generation among those individuals which have no posterity to inherit their peculiarities of structure.

The Honey Ants of Mexico offer additional difficulties. Among them a portion of the community secrete honey in the abdominal cavity until they resemble small grapes, and these individuals, during the winter, are despatched in succession to furnish food for the other members of the colony. How, by modified descent, is this honey-making faculty transmitted, when those who possess it are systematically destroyed?

A still harder nut for the Darwinians to crack is furnished in a fact stated by Dr. Stimpson, that among the crustacea, which do not live in communities, a very large proportion of the individuals of a numerically powerful species pass their lives as neuters or undeveloped females.

Another element in nature's economy, which at first sight suggests an objection to the Darwinian theory, is that of *beauty*, which affects others far more than the possessor. This is considered by the Darwinians simply as an attraction to the opposite sex, but as a fact we find that in the larval condition of some insects — a condition in which no propagation is effected — varieties of form and combinations of color exist which appeal to our sense of beauty scarcely less forcibly than in the perfect insects.

Again, the origin of life is left completely untouched by the Darwinian hypothesis, and so long as the vital principle resists, as it has done, all the efforts of theorists and experimenters to bring it within the category of material forces, so long we must regard the world of life as including elements not amenable to the laws which control simple inert matter.

Upon this question of the origin of life so much is being done and said that you will expect a word of reference to it at my hands, yet little more can be reported as the result of modern research than that the origin of life is as great a mystery as ever. You will all remember how, a few years since, we were startled by the announcement of the discovery of the generation of the "*Acarus Crossii;*" and, while our original distrust of the accuracy of the observations of Mr. Crosse was strengthened by the failure of subsequent experimenters to reproduce his results, our unbelief is further confirmed by the unanimity of all the more modern and intelligent devotees of spontaneous generation in the assertion that life can only originate in its simplest form, that of a unicellular organism. There is no Darwinist who will concede the possibility of an animal as highly organized as an *Acarus*, with body, head, limbs, digestion, and senses, all more or less complete, being the product of spontaneous generation and not the result of slow and gradual development.

Still farther; it is known that the animal kingdom rests upon the vegetable as a base. Animals being incapable of assimilating inorganic matter could not exist without plants. Plants must therefore have preceded animals, and the fruit of spontaneous generation must be a protophyte and not a protozoan.

Yet, notwithstanding its difficulties, there are to-day men, respectable by their numbers and attainments, who are believers in spontaneous generation; but it is with this proviso, — which leaves the mystery as great as ever, — that only from *organic* matter can organisms be produced. So that to the original and primary appearance of life upon the earth, modern science has given us not the slightest clew.

As I have said, the materialists have so far utterly failed to coordinate the vital force with those which we designate as material. The beautiful and important discoveries which have followed researches into the correlation and conservation of forces by pointing to a unity of all the forces in the material world have naturally prompted efforts to centralize, with electricity, magnetism, and chemical affinity, that which we know as vital force. But a moment's reflection will show us how far removed is this vital force from all others with which it has been compared.

The nicest manipulations of chemical science will probably fail to detect a difference in composition between the microscopic germs of two cryptogamous plants. Each consists of the same elements, — carbon, nitrogen, hydrogen, and oxygen, in nearly or quite the same proportions. Both may be planted in a soil which laborious mixture has rendered homogeneous, and subsequently supplied with the same pabulum, and yet, in virtue of some inscrutable, inherent principle, one develops an humble moss, and the other rises into the beauty, symmetry, and even grandeur of a tree fern. The same lesson is taught by the spermatozoa of the mouse and the elephant. Indeed, all the phenomena which attend the reproduction of species are totally at variance and incompatible with those which mark the action of material laws. Why, in physical circumstances differing *toto cœlo*, does the germ produce a plant or animal so closely copying the parent? and whence this tenacity of purpose in the germ which reproduces, through a long line of posterity, the trivial characteristics of a remote ancestor? Even within our limited observation, we have been struck by the reappearance in the grandchild of the voice, the gesture, the stature, the features, or some other marked peculiarity of his grandsire. Whence comes the force of the axiom that "blood will tell"? — and how incomprehensible that, by the action of only material laws, mental force, or, it may be, moral infirmity, is transmitted from generation to generation, in spite of the system of infinitesimal dilution through which it passes!

And now, even with this hurried and sadly imperfect exposition of the tendency of modern science, the time at our command has been consumed. Before leaving the subject, however, I crave your indulgence for a word to those who, wholly absorbed in the study of the laws which regulate the material universe, are so deeply impressed with their universality and potency that they forget that law is but another name for an order of sequence, and has in itself no force. These are they who, in their pride in the achievements of the human intellect, fail to realize that the universe furnishes conclusive proof that all our philosophy, all our logic, all our observation, are utterly inadequate to solve the problems that are presented to us, — inadequate not simply from the limited nature of our powers of observation, but because the human mind, though forced to confess the existence of the infinite, is utterly unable to grasp it; and that while the logic of reason and the logic of numbers suffice for a qualified understanding of the manner in which material forces work, of the origin and nature of these forces we are and must ever remain ignorant, unless gifted with higher powers than we now possess. As has been stated, seen from the stand-point of our modern materialists, and judged by the criteria which they have adopted, spiritual existence and supernatural phenomena, even if as all-pervading as the most devout religionist believes, must, from *a priori* considerations, be utterly ignored. Of those who are thus led by their regard for the dignity of material laws to reject the idea of a creative and overruling Deity, I would ask, Is not man himself a disturbing element in your universe? Whatever may be said in regard to man's free-agency, and however confidently it may be asserted that his will is but the resultant of the various motives that operate as distinct forces upon it, consciousness lies at the basis of all reasoning; and the conduct of every man proves that he accepts this axiom. As he issues from his door, he is conscious, beyond all argument, that it is in his power to turn to the right or to the left; and while he holds himself responsible for his volition, he cannot blame us if we ascribe to him free-agency. Man is, therefore, an independent power in the universe. He wills and creates. The locomotive is as truly his creation as himself, fashioned from the dust of the earth and vitalized by the breath of the Almighty, is the work of His hands. If, therefore, all the realm of nature is controlled through material laws, by forces that, like attraction, electricity, chemical affinity, etc., act in an invariable and inflexible way, in this universe man is a stupendous anomaly; and unless he can be degraded from his position of pre-eminence in this material world, the boldest and most irreverent of modern philosophers will strive in vain to dethrone the Great Creator from the rule of the universe, or from His place in the hearts and minds of men.

In consequence of the absence of President F. A. P. Barnard in Europe, an arrangement was made according to which Professor Newberry delivered the address at Burlington, and President Barnard is expected to give his own at the next meeting in Chicago, Illinois.

# PROCEEDINGS

OF THE

# BURLINGTON MEETING, 1867.

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## COMMUNICATIONS.

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## A. MATHEMATICS, PHYSICS, AND CHEMISTRY.

### I. MATHEMATICS AND ASTRONOMY.

### 1. COMMUNICATION OF VIBRATIONS. By BENJAMIN PIERCE, of Cambridge, Mass.

(ABSTRACT.)

ABOUT a year ago, my attention was drawn by Mr. Henry Waterman, of Hudson, New York, to a curious case of interchange of vibration between two pendulums. The pendulums were of equal weights and lengths, and hung from different points of a horizontal thread, which was perpendicular to their planes of vibration. A similar class of phenomena was studied experimentally about the beginning of the century by the celebrated *savans*, but it has never been investigated mathematically.

I have undertaken to consider the general case of the communication of vibrations between any number of vibrating bodies. I have reached the seemingly paradoxical result, that in a mathematical sense there is no such phenomenon. The mathematical formulas, rigidly interpreted, give us as many different states of possible vibration to each system as it contains different vibrating bodies. Each of these states might exist by itself, and, unless it were for the resistances of friction and so forth, would be permanently invariable, without any appearance which would suggest a communication of vibrations. The times of vibration of the different states would be different. Every possible state of vibration of the system can be decomposed into these elementary states, and shown to be an aggregate of them. As there is no communication of vibration in either of the elementary states, there is none in the aggregate. *The apparent* communication is, in reality, a phenomenon of interference of coexisting states of vibration which have different periods of vibration.

Thus in the case of Mr. Waterman's two pendulums, one state of vibration is that in which the two pendulums are in the same phase of vibration, so that they vibrate as one pendulum, a little longer than either of them, as is evident from the mode of suspension. The other state of vibration is that in which the two pendulums are in opposite phases, and, in this case, the time of vibration is a little less than that which belongs to either pendulum. When these two states are combined with equal amplitudes of vibration, each pendulum will come to rest at certain intervals, and alternates in such order and magnitude of succession as to satisfy the law of the preservation of power.

The same phenomenon would happen if the two pendulums had been restrained by the mutual connection of a spring, so that they could not recede very perceptibly from the same apparent phase of vibration. But in this case, the state of opposite vibration would be replaced by that in which the spring would be constantly subject to compression and the reverse. A clock, constructed with two such pendulums, would be subject to two different states, and would be liable to pass from one to the other, under circumstances which the observer could not regulate. I believe that this is the cause of the capricious change of late in the clock of the Cambridge Observatory. Were a clock to be constructed with three, four, five, six, or more pendulums, the necessary effect of such construction would be to introduce a corresponding number of different rates which would embarrass observation, and not to give one mean uniform rate, which would be the average of the rates of all the pendulums.

Were two clocks attached to the same pier, they would necessarily affect each other's rates in the same way, so that it is quite important in an astronomical observatory, to place the clocks in such isolated positions that there shall be no mutual influence between them.

## 2. On the Determination of Geographical Latitude from Observations in the Prime Vertical. By William A. Rogers, of Alfred, N. Y.

(ABSTRACT.)

THAT process of determining the geographical latitude of a place is the most advantageous which most completely eliminates instrumental errors and at the same time offers the greatest facilities for observation. It is my design, in this paper, to show that the method originally given by Bessel, and modified by Chauvenet, of deducing the latitude from equations of condition formed from single transits over the prime vertical, is especially adapted, either to the most exact determination in fixed observatories, or for use in topographical surveys, where only transient stations are established.

The following is the order of discussion observed: —

I. Discussion of star places, from the following authorities; viz., Bradley, 1755; Lalande, 1800; Piazzi, 1800; Groombridge, 1810; Bessel, 1825; Argelander, 1830; Struve, 1830; Pond, 1830; Airy, 1840; Robinson, 1840; Henderson, 1840; Airy, 1845; Radcliffe, 1845; Madras, 1850; Airy, 1850; and Airy, 1860.

II. Description of instruments.

III. Order of observation for 1866.

IV. Formation and solution of conditional equations for 1866.

V. Discussion of results for 1866.

VI. Order of observation for 1867.

VII. Formation and solution of conditional equations for 1867.

VIII. Discussion of results for 1867.

IX. Investigation of errors.

X. Discussion of the thesis that "The latitude may be more nearly determined from Fundamental Stars, passing the meridian at widely different distances from the zenith, than from stars passing the meridian near the zenith, taking into account the present uncertainty involved in the declinations of zenith stars."

XI. Some remarks on the availability of this method, as compared with the Zenith Telescope Method, in topographical surveys.

In 1866, no star has been used whose declination is more than 3° less than the latitude.

### RESULTS FOR 1866.

$\varphi$ is assumed $= 42° 15' 19''.2$.

| Date. | Position of instrument. | Weight=No. of observations. | $\Delta\varphi$ | mean $\Delta\varphi$, with weights. |
|---|---|---|---|---|
| June 13, | Circle South. | 4 | +1''.10 | |
| 14, | Circle North. | 4 | +1 .08 | +1''.09 |
| July 14, | C. S. | 4 | —0 .27 | |
| 15, | C. N. | 5 | +1 .54 | + .74 |
| July 24, | C. S. | | | |
| 25, | C. N. | 13 | | + .35 |
| July 28, | C. S. | | | |
| 29, | C. N. | 6 | | +1 .17 |
| July 30, | C. S. | | | |
| 31, | C. N. | 12 | | + .37 |
| Aug. 1, | C. S. | 7 | + .07 | |
| 7, | C. N. | 3 | — .65 | — .15 |
| | | | | Mean + .54'' |

$\varphi = 42° 15' 19''.74$.

For 1867 $\varphi$ is assumed $= 42° 15' 19''.80$, and the same stars were used as for 1866, together with Fundamental Stars taken from the American Ephemeris, varying in declination between 16° and 32°.

### RESULTS FOR 1867.

| Date. | Position of instrument. | Weight=No. of observations. | $\Delta\varphi$ | Mean $\Delta\varphi$, with weights. |
|---|---|---|---|---|
| April 17, | C. S. | 12 | — ''.01 | |
| | C. N. | 9 | + .44 | + ''.18 |
| April 28, | C. S. | 5 | + .66 | |
| | C. N. | 5 | — .27 | + .20 |
| April 28, | C. N. | 6 | — .06 | — .06 |
| June 4, | C. S. | 6 | + .50 | |
| | C. N. | 6 | — .80 | — .15 |
| June 5, } | C. N. | 10 | — .06 | |
| June 6, } | C. S. | 7 | — .25 | — .11 |
| June 13, | C. S. | 8 | — .92 | |
| | C. N. | 6 | + .88 | — .16 |

Mean $\Delta\varphi = - ''.01$.

and $\varphi = 42° 15' 19''.79$.

Combining the results for 1866 and 1867 by weights, there results:

$$\varphi = 42^\circ\ 15'\ 19''.78 \pm ''.08.$$

In order to find the effect of an error in observing the time of passage over the prime vertical upon $\varphi$, for stars of different declinations, I have selected eight Zenith Stars whose mean declination is 40°, and eight Fundamental Stars whose mean declination is 25° and which for distinction are designated Equatorial Stars. The corresponding hour-angle, $\vartheta$, is, for Zenith Stars 23°, and for Equatorial Stars 59°.

The probable error in $\vartheta$, designated $d\vartheta$, was found by comparing the observed with the computed intervals between the several threads, and from the values of $d\vartheta$ thus found the effect upon $d\varphi$ was computed by the following formula:—

$$d\varphi = \pm \frac{d\,\vartheta}{2} \sin 2\varphi \text{ tang. } \vartheta.$$

RESULTS.

ZENITH STARS.

| Star. | $\delta$ | No. int'v's compared. | $d\vartheta$ | $d\varphi$ |
|---|---|---|---|---|
| | ° ′ | ″ | ″ | ″ |
| d Herculis | 33 46 | 35 | ± .038 | ± 0.26 |
| 12 Canum | 39 2 | 28 | .043 | .16 |
| b Herculis | 39 11 | 35 | .064 | .19 |
| b Canum | 39 45 | 35 | .074 | .24 |
| 11 n Herculis | 40 51 | 28 | .083 | .20 |
| $b_1$ Bootis | 41 17 | 28 | .103 | .20 |
| $b_2$ Bootis | 41 21 | 42 | .167 | .32 |
| 19 Canum | 41 33 | 28 | .120 | .20 |
| | | | Mean | ± .22″ |

EQUATORIAL STARS.

| Star. | $\delta$ | No. int'v's compared. | $d\vartheta$ | $d\varphi$ |
|---|---|---|---|---|
| | ° ′ | | s | ″ |
| $\gamma$ Geminorum | 16 30 | 21 | ± 027 | ± 0.58 |
| $a$ Bootis | 19 52 | 21 | .032 | .25 |
| $\delta$ Geminorum | 22 18 | 21 | .030 | .45 |
| $\mu$ Geminorum | 22 35 | 21 | .032 | .46 |
| $\varphi$ Geminorum | 27 06 | 14 | .028 | .32 |
| $a$ Coronæ Bor. | 27 40 | 14 | .031 | .34 |
| $\beta$ Geminorum | 28 21 | 21 | .040 | .40 |
| $a$ Geminorum | 32 11 | 28 | .045 | .34 |
| | | | Mean | ± .43 |

The following table shows the probable error of $d\varphi$ from all sources

ZENITH STARS.

| | $d\varphi$ ″ |
|---|---|
| From error in observation, | ± .22 |
| " " dT = ± .75″, | ± .16 |
| " " $a$ = ± 1.5″, | ± .32 |
| " " $\delta$ = ± 1.2″, | ± 1.21 |
| " " reading level, | ± .47 |
| " " one div. level, | ± .15 × no. div. |
| Mean | ± .421″ |

EQUATORIAL STARS.

| | $d\varphi$ ″ |
|---|---|
| From error in observation, | ± .43 |
| " " dT = ± .75″, | ± .62 |
| " " $a$ = ± 4″, | ± .33 |
| " " $\delta$ = ± 4″, | ± .52 |
| " " reading level, | ± .57 |
| " " one div. level, | ± .15 × no. div. |
| Mean | ± .420 |

It is therefore obvious, that, in these particular observations, the total probability of error as effecting $\varphi$ is very nearly the same for the two cases. Of course with other stars and with other observers, these values would vary somewhat, yet the general result would not, I think, be affected. If now we take into account the great labor involved in the reduction of Zenith Stars, and the uncertainty in the element of proper motion, together with the fact that the use of Fundamental Stars greatly facilitates the increase of the number of observations, it is not doubtful, I think, where the advantage rests.

*It is my own experience that eight or ten carefully observed transits over the prime vertical, one half east and one half west of the meridian, and with the instrument in reversed positions, occupying from one to three hours in observation and from one to two hours in reduction, will give the latitude within ″.4.*

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## 3. REMARKS ON PERSONAL EQUATION IN TRANSIT OBSERVATIONS. By G. W. HOUGH, of Albany, New York.

(ABSTRACT).

THE "personality" of the eye, in recording transits by the magnetic method, was only considered. The total amount of "personality" may be separated into two distinct portions; viz., that due to the individual, and that due to the instrument.

The individual "personality," all extraneous conditions remaining the same, is not liable to very great change, either from day to day, or year to year. But the "personality" due to the instrument, or the method of observation, is subject to large variations.

The following conclusions were arrived at from the study of numerous experiments extending over a period of seven years. First, — The *absolute* "personality" as deduced from the observation of artificial stars, by means of the chronograph, is found to vary, for the same individual, from year to year, from day to day, and even from hour to hour; but the variation is always very small provided all the conditions of observation are the same. Second, — The absolute "personality" varies with the apparent motion of the moving object. The greater the apparent angular velocity, the less will be the personal equation. Hence it is concluded, that in the observation of transits the personal equation will vary with the declination; and also with the magnifying power of the telescope.

The difference of personality between two observers does not appear to be constant for stars of different magnitudes. From observations and experiments made during the past year, it appears that the difference is the least for bright stars, and greatest for faint ones. If subsequent investigations shall prove this conclusion to be correct, it will probably be found to be due to defective vision. In the observation of faint stars a feeble illumination is used and the wires are sometimes indistinct. But when a bright star is observed with the same illumination, the light of the star itself renders the wires distinctly visible.

The personal equation for the same individual varies with the kind of illumination employed. Observations made with illuminated wires are not directly comparable with those made with illuminated field. Our meridian instruments are so arranged that we can instantly pass from one kind of illumination to another. The transits of a large number of stars were observed, using illuminated wires for the first seven and illuminated field for the last seven, and *vice versa*. It was found that the difference between the two methods was well marked, amounting in the maximum to three tenths of a second of time.

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## 4. Observations of Venus near Inferior Conjunction. By C. S. Lyman, of New Haven, Conn.

A phenomenon of much interest, and, it is believed, never before observed, was exhibited by the planet Venus at the time of her last inferior conjunction (Dec. 11th, 1866), as seen in the Clark nine-inch equatorial of the Sheffield Observatory, at New Haven, — viz.; The extension of the cusps of the crescent so as to coalesce and form a complete ring of light.

The prolongation of the cusps beyond a semi-circle attracted attention on the 7th, when the planet was 6¼° from the sun, the arc of the crescent being then about 220°. On the 10th, from 10 A. M. to 3¼, P. M., the full ring was seen repeatedly by several observers. It was [illegible] exceedingly delicate and beautiful object, being, on the side opposite the sun, the merest thread of light. The observation was difficult, on account of the blaze of sunlight in the field, which there were no means of much reducing. Indeed, the full ring could not, in the circumstances, be seen constantly, but only when the glare of the sun was most diminished, and the atmosphere steadiest for definition. At other times, the crescent was easily seen extending, at least, 270°, and generally 300 or 320°. When latest observed, at 3½ o'clock, Venus was only 1° 8′ from the sun's limb. The nearest approach of centres was on the 11th at 9 hours 52 minutes A. M. No attempt was made to find the planet, as it was then less than 22′ from the limb. On the 12th, however, at 11 hours 30 minutes A. M., the completed ring was again observed, the planet's elongation from the sun's centre being then 1° 51′. Twice, when fortunately a passing cloud shut off the sun for a few moments, leaving the planet still visible, the view was particularly satisfactory. At other times, the coalescence of the cusps was seen, not constantly, but at favorable moments, as on the 10th. About 2 o'clock, the full ring was clearly seen with a Clark five-foot refractor of 4⅔ inches aperture and power of 90, by placing the telescope so as to have the sun behind a neighboring chimney.

With both telescopes, a marked inequality was noticed in the ring on the northern side, a portion of the delicate crescent being there fainter and slenderer than farther towards the point opposite the sun. This fainter arc was several degrees in extent, and, by estimate, about halfway between the point nearest and that farthest from the sun. It was seen also by Prof. Loomis.

On the 14th, the arc of the crescent was 231°; on the 15th, from 205° to 208°; and on the 18th, 196°. This arc was determined by estimate from cross wires made to quarter the disc, and also by measuring its versed sine with a filar micrometer. Owing to the difficulties of observation, these determinations are not as exact as could be desired, yet, from their general accordance, are believed to be pretty good approximations.

The extension of the cusps beyond a semi-circle has been observed before by Schroeter, Herschel, Mädler, and others, but they do not appear to have had an opportunity of following the planet into so close proximity to the sun as was possible at the late conjunction, and hence failed to observe the completed ring. Had the conjunction in 1866 occurred [illegible]enty-four hours earlier, there would have been a transit. Mädler, at Dorpat, in 1849, saw a maximum crescent of 240°, Venus being then 3° 26′ from the sun's centre (its nearest approach).

On the supposition that the phenomenon is due to the refraction of the planet's atmosphere, Mädler made the horizontal refraction, from his observations, 43′.7. My observations at the late conjunction give, by the same formula, 45′.3 as the mean, from six measurements of the cusps.

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## II. ACOUSTICS.

### 1. ON THE OPTICAL METHOD OF STUDYING SOUND. By JOSEPH LOVERING, of Cambridge, Mass.

WHEN the science of Acoustics is studied by means of the ear exclusively, we judge of the process simply by the result, that is, by the sensation. The optical method of investigation often gives us an insight into the process itself. Sound begins with a stationary vibration in the sonorous body; it is propagated by a progressive undulation; and it ends, physically and mechanically considered, in a vibration of some one of the three thousand nervous filaments discovered by Corti in the labyrinth of the human ear. Whether we regard the sound, therefore, at its origin, in its promulgation, or in the sensation, it is nothing but a vibration; and vibration is motion, and motion is the subject of vision. So that to see sound is only to see the motions which cause it. The only difficulty of seeing sound lies in the fact that the acoustic vibrations are upon a microscopic scale of magnitude, and, by their quick succession, the separate effects of individual vibrations blend into one sensation, in the eye as well as in the ear, by virtue of what is called in both cases the persistency of the impression on the organ of sensation. To overcome the first difficulty a beam of light is reflected from the vibrating body, or a mirror attached to it, which moves *in angle* twice as fast as the body itself, while the motion *in arc* may be amplified to any extent by increasing the length of the beam of light. The second difficulty is surmounted by reflecting the vibrations of the sonorous body itself, or some more visible effect which they originate, from a revolving mirror. By this device of looking at the image of the body, instead of the body itself, its vibrations, which coexist in space, are disentangled from each other, and movement vibrations, hundreds of which succeed each other in a single second of time, are translated into a long belt of space, in which even two successive ones do not overlap.

The optical method of studying sound embraces, in general, Savart's contrivance for discovering and exhibiting the nodal lines of plates by means of sand sprinkled over their surface, the investigation of the nodes and bellies of sounding strings by mounted riders, and of columns of air by a little drumhead suspended in the pipes, and more recently Lissajous' mirrors attached to tuning-forks, etc., Koenig's flames played upon by vibrating columns of air and reflected in a revolving mirror, and, finally, Melde's strings excited by the sympathetic vibration of an attached tuning-fork or bell.

The present communication is confined, however, to Koenig's reflected flames, in which are seen the individual vibrations of an organ pipe; by which can be beautifully demonstrated to the eye: First, — That the number of vibrations increases with the audible pitch; Second, — That coexisting vibrations produce maxima and minima of motion corresponding to the beats which are recognized by the ear; Third, — That one column of air will respond, in sympathetic vibration, to another when there is an agreement between their fundamental notes or some of their harmonics; Fourth, — That two unison-pipes, brought into intimate neighborhood, will move so that the vibrations of the air cross one another and produce silence, as Savart showed experimentally in the case of pendulums of equal length vibrating in company.

This peculiar case of unison-pipes I have made a subject of special investigation. In complex cases, it would doubtless be impossible so to arrange the voices and instruments that the total volume of sound should be multiplied in the same ratio as the number of performers. The effect of a large chorus or a large orchestra will disappoint expectation, from the unavoidable interferences of sound-waves. But in the simple case of two unison-pipes, can they be prevented from silencing each other? The remedy for the evil would be: First, — To sacrifice in a measure the perfection of the unison; or, Second, — to place them at a distance beyond each other's influence; or, Third, — to separate them by one-half of the wave-length which propagates a sound of the given pitch, or by some odd multiple of that quantity. The latter remedy would answer for auditors in the direction of the line which united the two pipes, though not for the audience generally. In studying the effect of position I have made the following experiments, the ear being the judge; or the eye, looking at the broken ribbon of light in the revolving mirror.

I. The pipes are placed side by side.
  1. With similar ends together, they silence each other.
  2. With dissimilar ends together, they silence each other.

II. The pipes are placed with their axes upon the same straight line.
  1. If similar ends are together, whichever of the two ends be selected, they silence one another.
  2. If dissimilar ends are together, they silence each other.

III. The pipes are placed at right angles to one another, with one extremity of each pipe at the angle.
  1. If the ends that are played are at the angle, the pipes reinforce each other.
  2. If the other ends are at the angle, they tend to silence each other.
  3. If dissimilar ends are at the angle, they reinforce each other.

In all these experiments the pipes employed were open at both ends.

Now that science is in possession of this delicate optical method, which requires for its success no nice musical ear, other problems, heretofore settled by assumption, may be brought within the range of demonstration.

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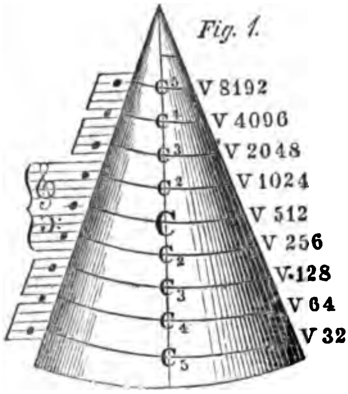
## 2. On a Method of Measuring Musical Intervals upon a Spiral Projection. By Samuel D. Tillman, of New York, N. Y.

Vibrations, producing the different sounds of the diatonic scale, have fixed numerical relations. Starting from the first or lowest sound, and proceeding upward, the eighth sound is found to harmonize most perfectly with the first; proceeding still upward, the fifteenth is found to harmonize just as perfectly with the eighth, and the twenty-first with the fifteenth. Each of these four sounds are, therefore, regarded as the first in a distinct, but similar, series, embracing seven sounds. The vibrations producing each sound of the first series are, to those causing a similar sound in the second, as 1 to 2. This natural division of musical sounds into septaves is not clearly shown when the characters or signs representing these sounds are arranged in one right line, as found in all popular systems of instruction; moreover, the ear, in demanding the addition of the octave, as the terminal note of the diatonic scale, helps to mislead.

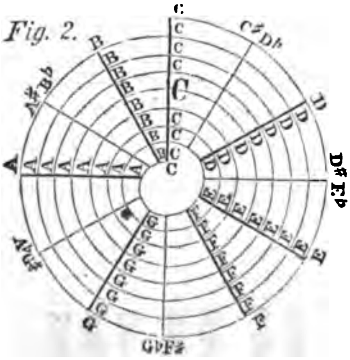
To obviate this difficulty, I represent the progress of pitch, from the lowest to the highest musical sound, perceptible to the human ear, by a line passing spirally around a cone, as seen in Fig. 1.

Fig. 1.



Each ring measures a septave. A right line drawn from the apex to the base of the cone cuts the spiral at each point where there is an apparent return to the tonic by a repetition of the octave. All the sounds known as C are shown. On the right is the number of vibrations producing each, assuming that the middle C has 512, or is the ninth octave of an imaginary sound, having one vibration per second. The French standard pitch requires for this sound 522 vibrations per second. On the left are the positions of all the notes C on the staff, as fixed by the base and treble clefs.

Fig. 2.

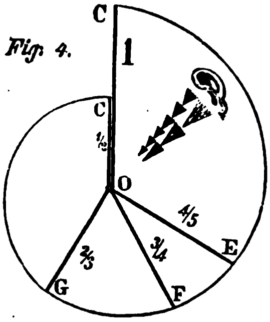


Twelve similar right lines, at equal distances around the cone, would represent the intervals of the chromatic scale, as made by keyed instruments; and seen from the top of the cone, they would appear, as shown in Fig. 2, which measures all the intervals made on the largest sized organ.

The true spiral projection, representing a single septave, is shown in Fig. 4. The line CO being the length of a string or pipe giving the sound C; and c O. a similar string or pipe, half as long as the first, which gives a sound an octave higher than the first sound. The perfect concord of these two sounds arises from the fact that every wave of air producing the lower sound strikes the ear simultaneously with every other wave causing the octave.

The intermediate sounds of the diatonic scale would be measured on the septave by lines proportionate to the length of strings or pipes producing such sounds. Only three are shown at E, F, and G. The ratio of the vibrations producing these sounds respectively with those producing C being as 4 : 5, 3 : 4, and 2 : 3. The generation of a spiral on this plan, to embrace every septave, requires that the length of the radius vector should be doubled with every revolution of the generatrix, and would, therefore, on account of its size, be quite inconvenient. For general use I substitute a true circle for one ring of the spiral, and divide it into twelve equal parts or grades to represent the tempered intervals of one septave, as made by keyed instruments. It resembles the ordinary watch dial, 12 being the starting-point or the tonic of the natural key. The position of the figures on a watch-face being so early learned and so familiar to every one, there is but little difficulty in adapting them to musical intervals. Inverting the circle of figures, its application to the keys of a piano, or an organ, are shown in the annexed illustration, Fig. 5.

Fig. 4.



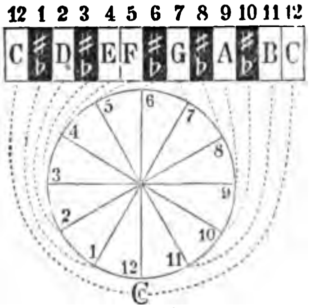
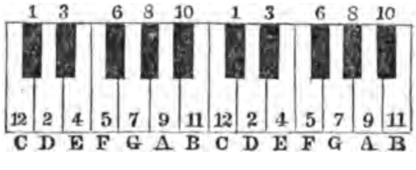


Fig. 5.

Two septaves of keys are shown in Fig. 3. The numbers 12, 2, 4, 5, 7, 9, 11 correspond with the letters designating the notes of the natural key of C, while the numbers 1, 3, 6, 8, 10 designate notes used in other keys. This application of numbers to the twelve sounds embraced in a septave obviates the necessity of sharps and flats which do not properly belong to the tempered system employed on keyed instruments.

Fig. 3.



The position of the numbers used in the key of C, on the staff, as fixed by the base and treble clefs, are shown in Figs. 6 and 7.

*Fig. 6.*

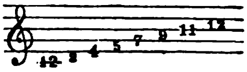
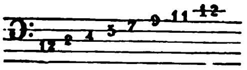


*Fig. 7.*



These preliminary statements will make plain the use of my Tonometer, which measures to the eye all musical intervals. (The instrument was here presented by the speaker, and illustrated on the blackboard.) It consists of a sheet or plate containing a circle divided into spaces representing the intervals of the true as well as the tempered system. A division of the circle into equal spaces, so as to measure by multiples of one such space all intervals that can be made by modulations, would be so minute as to be of no practical service. I have substituted a near approximation to the true intervals by dividing the circle into fifty-three equal parts called commas. The comma used is the difference between the first and the second intervals of the diatonic scale, expressed by the ratio of $\frac{81}{80}$. Taking the ratio of the air-waves producing each sound of the true septave with those producing the tonic, and deducing the ratio of the several sounds with each other, we have the following ratios of intervals: $\frac{9}{8}$, $\frac{10}{9}$, $\frac{16}{15}$, $\frac{9}{8}$, $\frac{10}{9}$, $\frac{9}{8}$, $\frac{16}{15}$. The first three ratios being nearly as the whole numbers 9, 8, 5, we may measure the so-called major-tone, minor-tone, and semitone intervals of the septave by 9, 8, 5, 9, 8, 9, 5 = 53, or the whole number of units in the circle.

The same circle is also divided into twelve equal parts representing an isotonic temperament of the chromatic scale, applicable, however, to keyed instruments tuned by allotonic temperaments.

Within this fixed circle is a movable circular disk, having upon it the same divisions representing the true and tempered intervals. As the notes of the septave have the same fixed relation, it is evident that the position of the movable tonic at any pitch shown on the fixed circle will determine the position of every other note on the same circle. The notes of the septave represented on the disk are distinguished by the common syllables used in solfeggio, and the numbers by which they are known in figured base. Within the movable circle, representing the intervals, and in the major mode, is another series of signs, representing the notes of the minor mode. Thus completing the symbols for one key, by turning the tonic sign from C to G, D, A, E, B, and F sharp respectively, we see at a glance the notes belonging to each key in a modulation by sharps. Again, starting from C and passing to F, B flat, E flat, A flat, D flat, and G flat, we find, in turn, the sounds belonging to these several tonics. The employment of numbers in the place of letters renders these changes in modulation much more simple, and obviates the unwarrantable use of the terms "flat" and "sharp." In a modulation by sharps, seven, added to the last tonic, gives the next succeeding one; thus 12, 7, 2, 9, 4, 11, 6. In a modulation by flats, 5 is added; thus we have 12, 5, 10, 3, 8, 1, 6, as the regular order of tonics. Both series begin and end with the same figures. The seven sounds used in each modulation are determined by this simple rule; viz., If the tonic is an odd number, the next two notes are odd, and the remaining four, even; *vice versa,* if the tonic is an even number, the next two notes are even, and the remaining notes odd.

A synopsis of chords expressed by the solfeggio syllables is adapted, by means of the revolving disk, to the twelve different modulations made by keyed instruments.

The relations of sound and color are shown by applying the colors of the solar spectrum to the seven intervals of the septave. Red, made by the lowest number of undulations, represents the tonic; yellow, the mediant; and blue, the dominant. I have elsewhere pointed to the very curious coincidence arising from this arrangement of colors; the darkest color, indigo, falls on the relative minor tonic; and the brightest, yellow, on the brilliant mediant; from which the deduction is made that light, heat, and actinism result from the undulations of the same attenuated medium; that the two forces last named vary inversely as the length of undulations, while the perception of light and color results from the ratio of undulations embraced in a single octave.

The intervals of the three major and three minor common chords are respectively measured by 4, 3, and 5 grades and 3, 4, and 5 grades. Discovering that, in each case, the sum of the squares of the first two numbers was equal to the square of the third number, I was led to represent these triads by right-angled triangles. In *comma* terms the equation is $17^2 + 14^2 = 22^2 + 1$. The same terms show that twelve consecutive fifths overlap seven consecutive octaves, that is, $31 \times 12 = 53 \times 7 + 1$.

Further deductions have been made which are, however, foreign to the purpose of this paper, but this singular relation of lines and angles to the harmony of color, as well as sound, does suggest that there are certain connecting links between form and motion, the discovery of which may reveal, partially, at least, those processes of nature, producing both permanency and growth; and that, eventually, man may comprehend the operation of those wave-forces which, by harmonious blending, shape cell and crystal and define the forms of leaf and flower.

In conclusion, I would advocate a change in the solfeggio syllables which gives each a vowel termination, and, at the same time, assists the vocalist in determining their harmonic relations. This slight reform only carries out what seems to have been the original intention of the early masters. The Greeks applied to their tetrachords the syllables *Ta, Te, The, Tho.* Although their system was early supplanted by the septave, no improvement in solmization was made until, in the eleventh century, Guido Aretino designated the first six sounds by different syllables. He was led to their use by noticing a marked relation between the ascending sounds given to the first syllables of the following Hymn to St. John: —

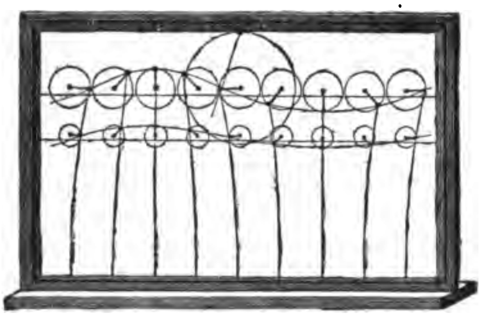
Ut queant laxis,
Resonare fibris,
Mira gestorum,
Famuli tuorum,
Solve polluti,
Labii reatum,
Sancte Johannes.

Regarding this discovery as a special revelation to him, he did not venture to complete the scale, which was done long after his time by adding *si.* The consonant ending of two of these syllables was not favorable to prolonged vocal sound. *Ut* was afterward replaced by *do.* The *l* in *sol,* when followed by *la* did not seem so objectionable, and sol has held its place among syllables which have been used in solmization for eight hundred years. Guido's scale commenced on G, and was sometimes designated by the Greek name, *Gamma,* also by *ut,* from whence arose *Gammut*; thus the discarded *ut* has found a permanent place in the name of the scale. The change I propose is the substitution of *To* for *do,* and of *do* for *sol;* thus *To* will always be found on the Tonic; *mi* on the Mediant; and *do* on the Dominant; and To-mi-do will express the common chord now known as the *first*, *third*, and *fifth*. All chords may be indicated by a combination of solfeggio syllables, and numbers only used to designate the twelve grades of the spiral which represent the twelve intervals of the tempered system.

### 3. On a New Form of Wave Apparatus.

By C. S. Lyman, of New Haven, Conn.

The class of waves which this piece of mechanism was designed to illustrate is that whose type is the ordinary ocean wave in deep water. The apparatus exhibits not only the wave profile with its progressive motion, but also the motions taking place below the surface, in the whole mass of liquid affected. Since the motions in the apparatus are essentially the same as in nature, the leading geometrical and dynamical facts pertaining to the theory of waves are presented with completeness, and in their true relations. The wave theory illustrated is that established by Gerstner, Scott Russell, Rankine, and others, and which teaches that, in such waves, all the particles are revolving synchronously, and in the same direction, in vertical circles. An able analytical exposition of it, by Prof. Rankine, is contained in the *Philosophical Transactions* for 1863.*



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* It is somewhat singular that this theory, though more than half a century old, has, nevertheless, but just begun to supplant, in the text-books, that which explains wave motion as a vertical oscillation of neighboring liquid columns, as in the two branches of a U-shaped tube, a theory commonly credited to Newton; though Newton, in fact, only used it as a convenient approximative hypothesis for a particular purpose, not as a theory true to nature, remarking in conclusion, "Hœc ita se habent ex Hypothesi quod partes aquæ recta ascendunt vel recta descendunt; *sed ascensus et descensus ille verius fit per circulum.*"

The construction of the apparatus is simple. In front of a plane surface are two series of revolving arms or cranks, the length of the lower ones being half that of the upper. Two elastic wires connect the crank-pins of each series; upright wires also connect each pair of cranks, and pass down through a plate into the base. The cranks all revolve synchronously; they thus keep their relative position, and come into any particular position successively, each in its turn. The relative position of the cranks of each series is such, that the directions of any two, in regular order, differ by the same fraction of a whole revolution that the distance between their axes is of a whole wave length. In the apparatus, the length of a wave is divided into eight equal portions, and hence, the common difference in the directions of the crank-arms is one eighth of a circle, as shown in the figure. The positions of the cranks in each vertical set are always alike. The number of cranks, whether reckoned horizontally or vertically, is arbitrary, — a matter of convenience. Their synchronous revolution is produced by any suitable mechanism, such as toothed wheels, rag-wheels with endless metallic ribbon or chain, or cranks and connecting frame. In the original machine, equal toothed wheels, one on each axis, with intermediate idle-wheels, give the required motion. For small machines the third method is used, as in the model for the Patent Office.

The crank-pins represent as many liquid particles, and the circles behind the crank-pins their orbits. The transverse wires represent lines of equal pressure, or continuous lines of particles, which at rest would be horizontal, and so coincide with the lines drawn just below the centres of the orbits, the upper one of these being the surface line, the lower one a line of particles one ninth of a wave's length below. The upright wires represent lines of particles which at rest would be vertical. Every point in these moving lines describes its own distinct orbit. The spaces between the wires show the varying distortions of sections of water originally rectangular.

The radius of the large circle is made such that its ratio to the radius of a particle's orbit is equal to the ratio of gravity, or the weight of the particle, to its centrifugal force; or, putting $R$ and $r$ for the radii respectively, and $t$ for the time of revolution, we make $R : r :: g : \frac{4\pi^2 r}{t^2}$; hence, $t = 2\pi\sqrt{\frac{R}{g}}$, which is the period of a revolving pendulum whose height is $R$. Such a pendulum, then, will keep time with the wave.

The force acting on a particle being the resultant of its weight and centrifugal force, if the latter be represented, in intensity and direction by the crank-arm or radius vector of the particle, the former, or gravity, will be represented, similarly, by the vertical radius of the large circle, and the resultant of the two by the third side of the triangle, or a line drawn from the top of this radius to the particle. The wire pendulum represents this resultant, and, like it, is always normal to the wave surface.

The measure of the resultant force being the distance on the wire pendulum from its point of suspension to the wave surface, it is seen that when the particle is at the top of its orbit, the acting force is its weight minus its centrifugal force; when, then, the centrifugal force equals the weight, as in high short waves, the resultant becomes zero, and the particle, no longer held by gravity, flies from the crest in foam.

Since the wire-pendulum is always normal to the wave-curve, its entre of oscillation is the instantaneous centre about which may be described an element of the curve at the point of normalcy. Hence if this circle be rolled along under a horizontal straight line, a point within it, at a distance from its centre equal to half the height of a wave, will describe a trochoid, which is the wave profile. Consequently, the circumference of the rolling circle is equal to the length of a wave; and the period of a wave is that of a revolving pendulum whose height is the radius of the same circle.

If the describing point be taken in the circumference of the rolling circle, the curve is an inverted cycloid. The cycloidal cusp, then, is the limit of sharpness of a wave's crest, the radius of the orbit being, in that case, equal to that of the rolling circle, or, in other words, the particle's centrifugal force equal to its weight. All possible wave profiles, therefore, are trochoids of curvatures ranging between the limits of the cycloid on the one hand, and the straight line on the other, or between the sharp crest breaking in foam and the level of still water. The greater sharpness of the crests than of the troughs, with its cause, is conspicuous in the apparatus.

It is seen also that the crests rise higher above the level of still water than the troughs fall below it. The difference is equal to twice the height due to the orbital velocity of the particle, or is a third proportional to the radius of the rolling circle and the radius of the particle's orbit; that is, putting $R$ and $r$ for these radii respectively, and $D$ for the difference in question,

$$D = \frac{r^2}{R}.$$

The rolling circle is the same for all wave profiles (or surfaces of equal pressure) down to still water, the tracing arm, or orbit-radius, only becoming shorter in a geometrical ratio, with increase of depth. The rate of shortening is approximately one half for each additional depth equal to one ninth of a wave's length; or, more exactly, putting *r* and *r′* for the radii respectively of a surface orbit and of one whose middle depth is *k*, it is

$$r' = r\, e^{\frac{k}{R}},$$

R being the radius of the rolling circle, and *e* the base of the Naperian logarithms.

The distance of the crank-axes above the horizontal lines on the background corresponds to the distance of the orbit-centres of corresponding particles in wave motion above the position of the same particles when at rest; this distance is a third proportional to the diameter of the rolling circle and the radius of the particle's orbit, or is equal to the height from which a body must fall to acquire the orbital velocity of the particle, or, is equal to the area of the orbit divided by the length of the wave; that is, putting *h* for this distance, *l* for the wave's length, *v* for the orbital velocity, and the other symbols as before,

$$h = \frac{r^2}{2R} = \frac{4\,\pi^2\,r^2}{2\,g\,t^2} = \frac{v^2}{2g} = \frac{\pi\,r^2}{l}.$$

The length of a wave whose period is *t* is

$$l = 2\,\pi\,R = \frac{g\,t^2}{2\,\pi};$$

the period

$$t = \sqrt{\frac{2\,\pi\,l}{g}} = 2\,\pi\sqrt{\frac{R}{g}};$$

and the velocity of propagation of such a wave

$$V = \frac{l}{t} = \frac{g\,t}{2\pi} = \sqrt{\frac{g\,l}{2\,\pi}} = \sqrt{g\,R}.$$

The motion of the wire-pendulum represents the motion of the mast of a raft floating on the wave's surface; the upper portion of each upright wire shows the motion of a long, thin body floating in a vertical position, as a board end down; the varying inclination of the two bodies, or wires, to each other shows the kind of strain produced by wave-action on a floating body both broad and deep, such as the hull of a vessel.

In shoal water, the orbits are no longer circles, but ellipses or ovals, with the eccentricity increasing as the depth diminishes, while the front slope of the wave becomes increasingly steeper than the back, until the crest finally curls over and breaks in surf.

The apparatus has been patented, and is manufactured by Messrs. E. S. Ritchie and Son, of Boston.

## III. PHYSICS AND CHEMISTRY.

### 1. TELLURIUM, A METAL.[*] By L. BRADLEY, of Jersey City, N. J.

BY the kindness of Dr. L. Feuchtwanger, of New York, I am permitted to exhibit this piece of Tellurium. He informs me that it was extracted from a combination of Tellurium and Gold, discovered on the Stanislaus River, in Calaveras County, California.

At a recent discussion before the Polytechnic branch of the American Institute, in reference to it, a question arose as to its metallic nature, and its power of conducting electricity. Whereupon I obtained permission to take it and test its conductivity as compared with several other substances. I procured pieces of about the same dimension [half-inch square by three-fourths inch long] of zinc, magnesium, cast iron, graphite, several pieces of coke, black oxide of manganese, sulphuret of antimony, and sulphur; also an appliance for conveniently connecting them, one at a time, into a circuit of short, coarse wire, designed to conduct a current of electricity, generated by four cups of Hill's battery. The battery being arranged as compound battery, i. e., the positive pole of one cup connected with the negative of the next, and so on, and using the tangent galvanometer for intensity, I obtained the following deflections; viz.: —

| | |
|---|---|
| With no Substance | 80° |
| " Tellurium | 80° |
| " Zinc | 80° |
| " Magnesium | 80° |
| " Cast-iron | 80° |
| " Graphite | 79° 5′ |
| " Coke | 79° 20′ to 80° |
| " Manganese | 19° 20′ |
| " Sulphuret of Antimony | 0° |
| " Sulphur | 0° |

With the cups arranged as simple, or quantity battery, — i. e., the positive poles connected, and the negative poles connected, — the deflections were

| With | Quantity Galv. | Intensity Galv. |
|---|---|---|
| No Substance | 28° 20′ | 62° |
| Tellurium | 26° 50′ | 62° |
| Zinc | 27° 40′ | 62° |
| Magnesium | 27° | 62° |
| Cast-iron | 27° | 62° |
| Graphite | 15° 10′ | 61° |
| Coke | 20° to 27° | 61° 10′ to 62° |
| Manganese | 0 | 0 |
| Sulphuret of Antimony | 0 | 0 |
| Sulphur | 0 | 0 |

This shows how little capable a quantity current is of overcoming resistance; for, even the manganese, which, under the intensity current, admitted a deflection of 19° 20′, under this, seemed like a perfect insulator, even by the very sensitive quantity galvanometer.

Tellurium heats readily, though not quite so rapidly as zinc, and it cools a little more slowly.

It is not to be expected that, with pieces so small, and with so weak a battery, very nice and exact results are to be attained; but the foregoing are sufficient to show that Tellurium is a good conductor of both heat and electricity; and we see that it possesses a brilliant metallic lustre.

The question arises, therefore, why is it that chemists, especially those of France, have recently ranked it among the non-metallic substances?

Metallic lustre and conducting power have always been looked to as the distinguishing characteristics of metals. Kane says, "By the combination of these two characters, lustre and conducting power, the metallic, or non-metallic nature of a body is always distinguished."

It is true that Tellurium is not malleable nor ductile, as are many of the metals; neither is bismuth or antimony. Like the non-metallic substances, it unites with *oxygen* to form acid. So do antimony, arsenicum, gold, chromium, manganese, and many other metals. With *hydrogen* it unites, forming a hydruret; so do potassium, arsenicum, and antimony. In short, it possesses the universally admitted distinguishing characteristics of metals; and nothing, either in physical character or chemical behavior, which it does not hold in common with some other metals. I must therefore call it a metal.

## 2. PRELIMINARY NOTICE OF EXPERIMENTS ON SNOW AT TEMPERATURES BELOW 32° FAHRENHEIT. By EDWARD HUNGERFORD, of Burlington, Vt.

(ABSTRACT.)

THIS paper gave full details of a series of experiments, conducted by the author, to determine the effect of pressure upon snow, at temperatures below the melting point. The experiments raise a serious doubt as to the correctness of the assertion that snow cannot be converted into ice by pressure at those temperatures. By *prolonged pressure* the glacification of the snow was effected under such conditions as did not seem to admit either of the elevation of the temperature of the snow to 32°, or of its liquefaction through depression of the melting point. It is claimed that the prolongation of the pressure gives time for the air to escape from the meshes of the snow, thus permitting intimate contact between the particles, when union takes place, resulting in transparent or semi-transparent ice.* The method of conducting experiments was explained and apparatus exhibited. The important bearing of these experiments on the subject of the glacification of the *névé* and on the theories of regelation leads the author to propose to continue them during the coming winter.

## 3. CHEMICAL DIAGRAMS AND DERIVATIVE SYMBOLS, ILLUSTRATING THE PROMINENT CHARACTERISTICS OF CHEMICAL ELEMENTS. By SAMUEL D. TILLMAN,† of New York, N. Y.

CHEMISTS now recognize at least 64 different kinds of ponderable matter which have not, thus far, been decomposed, and are therefore regarded as simple bodies. Of these 51 are called metals and 13 non-metallic elements. French chemists do not draw the line of distinction so broadly, since several of the non-metallics possess nearly all the characteristics of the metals. They recognize 49 of the elements as metals, and designate the remaining 15 as metalloids. The objection to this classification is, it assumes that all elements which are not metals are *like* metals. Seven of these metalloids are strongly electro-negative, and in their general behavior bear no resemblance to metals.

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* This explanation was not so distinctly stated in the paper. — E. H.

† Diagrams and illustrations in this paper, entered to Act of Congress in the year 1867, by S. D. TILLMAN, in the Clerk's Office of the District Court of the United States for the Southern District of New York.

On examining the non-metallic elements, it will be found most convenient to classify them according to the state or condition which they assume when isolated.

Three elements are remarkable for their hardness or impenetrability, namely, CARBON, BORON, and SILICON. They are denoted by a pyramid in the centre of the first diagram.

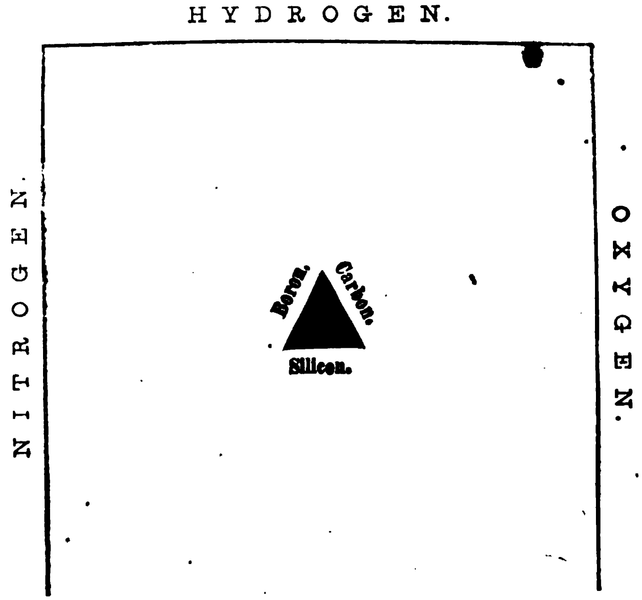


*Fig.* 1.

The three boundaries of one face of a pyramid will respectively represent these three elements. SILICON or SILICIUM fuses at about 1,450° Centigrade, the melting point of steel. BORON is reduced only at a still higher heat. CARBON, when perfectly isolated and surrounded by substances with which it has no affinity, remains solid and infusible under the highest heat thus far applied.

As the antipodes of these hard elements, we have three gases, which, under the greatest degree of cold and of pressure yet applied to them, have not been reduced to the solid or even to the liquid state. They are OXYGEN, NITROGEN, and H[illegible]ROGEN.

The three lines in Fig. 1, furthest from the centre, represent these attenuated elements. To the class of simple gases also belong FLUORINE and CHLORINE which are represented by the lower lines in Fig. 2. Thus the five gases are designated by the five boundary lines of the diagram. FLUORINE is the only element which has not been obtained in a separate state; nevertheless, considerations, which need not here be presented, justify the assumption that Fluorine, when isolated, is a colorless gas.

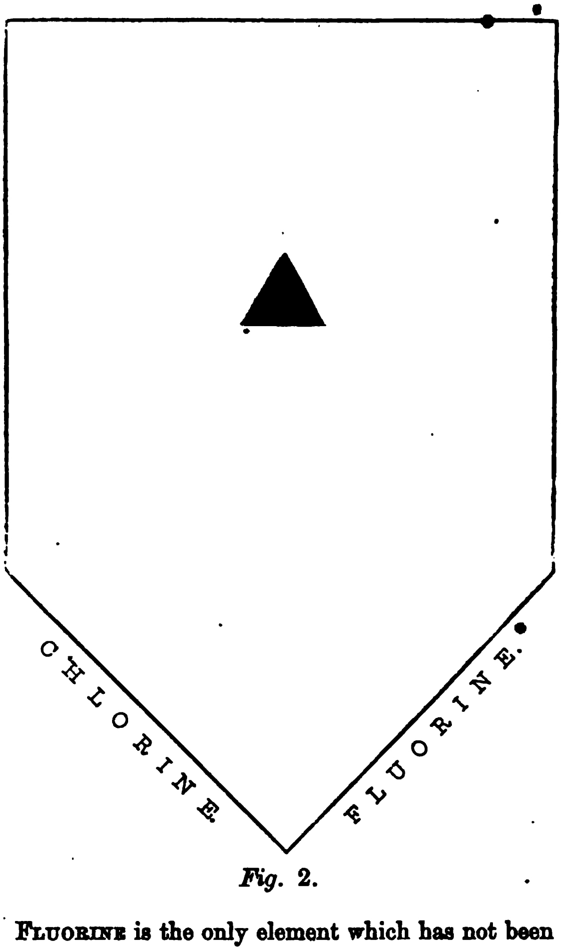


*Fig.* 2.

CHLORINE is a transparent greenish yellow gas at ordinary temperatures. When subjected to a pressure of about 60 lbs. to the square inch, it becomes a yellow liquid; yet, when cooled to 140° C, it still remains unfrozen.

Between the three hard elements and the five gases, are found five non-metallic elements which readily pass from the solid to the gaseous state on being heated, viz., Bromine, Iodine, Sulphur, Selenium, and Phosphorus. If the French view is adopted, we must include as metalloids Arsenic and Tellurium. These *seven* elements are shown in Fig. 3, which is so arranged as to represent the solid state of the element

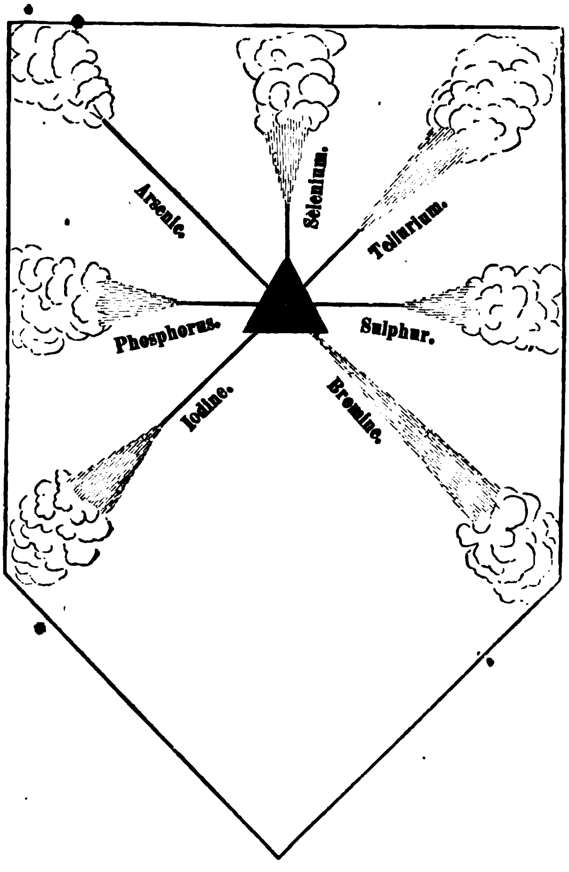


*Fig.* 3.

by a thick line nearest the centre, then the liquid, and lastly, the state of vapor near the outside of the diagram.

It will be observed that Bromine is not represented by a thick line, because at ordinary temperatures it is a liquid. Bromine becomes a solid at 12°.5 C, and boils at 63° C.

**Iodine** melts at 107° C, and changes into a splendid blue vapor at 175° C.

**Sulphur** melts at 115 C, and becomes a deep yellow vapor at 440° C. Sulphur has several modifications of form, or different allotropic states, in each of which it is differently affected by heat.

**Selenium** melts at a little over 100° C. In the crystalline form it softens at 217° C, and does not become completely fluid until above 250° C. Heated in a close vessel, it boils at a little above red heat.

**Tellurium**, which has the appearance of a metal, fuses a little below 480° C, and at a high temperature becomes vapor.

**Arsenic** is not known in a liquid state. At 180° C, it begins to volatilize without fusing. This peculiarity is represented by a thick line extending from the centre to the point, where it is shown as a vapor. This element, as well as Tellurium, I prefer to class among the metals.

**Phosphorus** melts at 45°, and boils at about 299° C.

The metals are solid at ordinary temperatures, with the exception of Mercury, a fluid which freezes at 39° C, and becomes a colorless vapor at about 360° C. A large majority of the metals melt at a high temperature; yet several of the light metals, of the alkaline class, become fluid a little below the boiling point of water.

The fifty-one metals — including Arsenic and Tellurium — are represented by the radial lines in Fig. 4; the shaded line projecting downward from the centre denotes the fluid, Mercury.

*This diagram includes all the known elements.* It is arranged so as to show with clearness their classification as fifty-one metals and thirteen non-metallic bodies, also their consistencies when in a separate state at ordinary temperatures, thus embracing

5 Gases.
2 Liquids.
57 Solids. Total, 64.

The gaseous elements are again represented by Fig. 5.

Hydrogen, the lightest, is placed at the top; Fluorine and Chlorin, the heaviest two, at the bottom; Oxygen and Nitrogen have an intermediate position on the sides. Equal parallelograms, projecting from the sides of the figure, represent equal measures or volumes of each gas at the same temperature and pressure; and the wide mark, or bar,

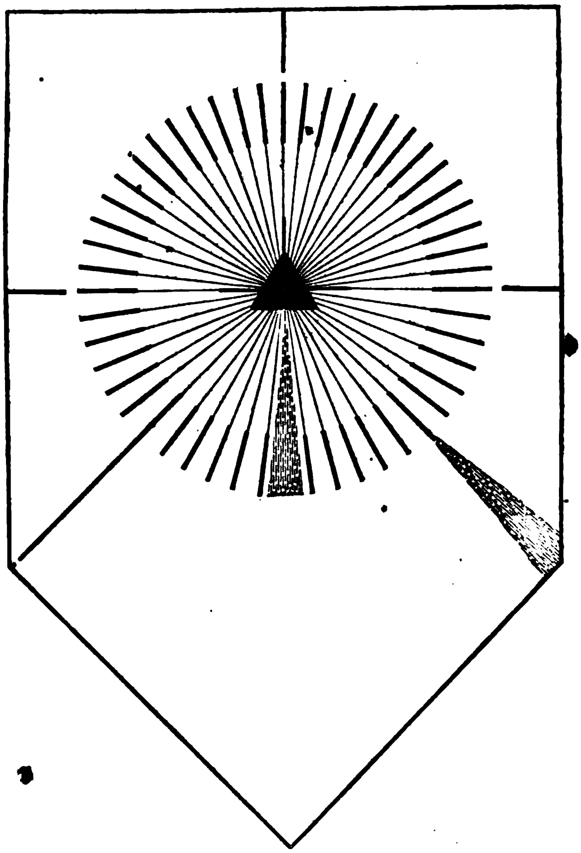


*Fig.* 4.

within each parallelogram, shows its relative density or specific gravity. Assuming that one volume of Hydrogen weighs 1, then one volume of Nitrogen will weigh 14; one of Oxygen, 16; one of Fluorine, 19; one of Chlorine, 35.5. As these gases unite in equal volumes, or multiples of equal volumes, in forming chemical compounds, the smallest portion which can enter into combination may be distinguished as an atom, therefore the bars designating the density of the gases may

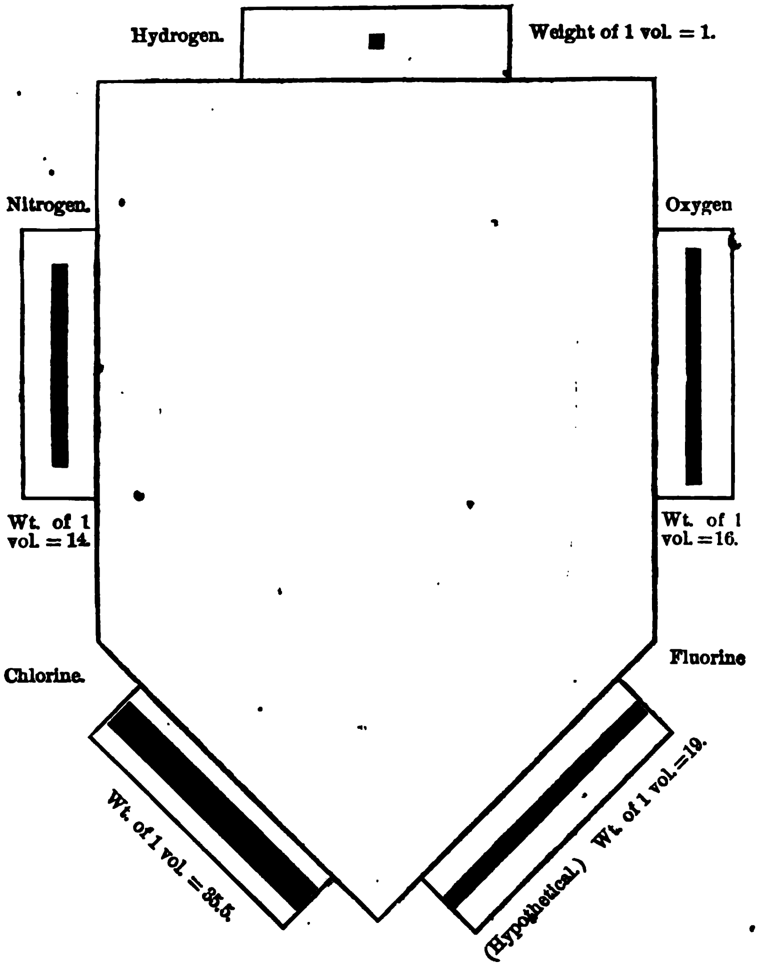


*Fig.* 5.

be taken as the relative weight of atoms which are supposed to be of equal size. The conception of an atom must not be limited by size and weight. It is, in fact, a source of force. Several years ago, I advanced the hypothesis that the ultimate atom is a hollow sphere, containing, and surrounded by, the imponderable ethereal element, and incessantly moving to and from its own centre. Whatever may be its condition in chemical combination, it assumes its original form and motion on being released and isolated.

The arrangement of the elementary gases in Figs. 2, 3, and 4 has another important signification. Oxygen unites with all other elements except fluorine, and is electro-negative. From the position of Oxygen passing around the diagram downward and then upward; we find these gases in the order determined by electrolysis, — Hydrogen being electro-positive to the other four.

The non-metallic elements, or metalloids, belonging to the same family are placed, as shown in Fig. 3, in close proximity, so that their atom-holding, or saturating power, in chemical combination, may be clearly understood.. Hydrogen, Fluorine, Chlorine, Bromine, and Iodine, having the lowest atom-holding power, are monatomic, or monads. Oxygen, Sulphur, Selenium (also Tellurium), are diatomic, or dyads. Nitrogen, Phosphorus, Boron (also Arsenic), are triatomic, or triads. Carbon and Silicon are tetratomic, or tetrads.

The chemical combination of two gaseous elements and the resulting volume are also illustrated by a series of diagrams. It is supposed that not less than two atoms of each element enter into combination; however, the process is rendered more intelligible by representing the union of single volumes. Fig. 6 shows the combination of a volume of Hydrogen with one of Chlorine, which, under the influence of light, unite without condensation, and form two volumes of hydrochloric acid gas.

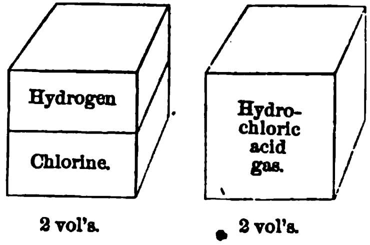


*Fig.* 6.

Although the resulting product of the union of these gases is not diminished in bulk, yet, at the instant each electro-positive atom seeks an electro-negative, there is expansion. This process of the mating of atoms produces explosion.

Fig. 7 represents two volumes of Hydrogen and one of Oxygen, entering into combination and forming steam, which is condensed to two volumes, or two thirds of the original bulk of these gases in a separate state.

Below 100° C the steam is condensed to nearly one seventeen hundredth of its volume. As one cubic foot contains 1,728 cubic inches, we may say that two cubic feet of Hydrogen and one cubic foot of Oxygen combine and form two cubic feet of Steam, which may be condensed to about two cubic inches of Water.

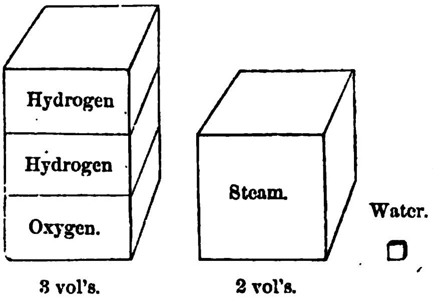
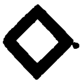


*Fig.* 7.

Fig. 8 represents three volumes of Hydrogen combining indirectly' with one of Nitrogen, and forming two volumes of ammonia. Thus four volumes are condensed to two, the resulting product being one half of the bulk of the combined gases. To express this combination in accordance with the new atomic theory, we should say three atoms of Hydrogen and one atom of Nitrogen combine to form an atomoid of ammonia. By using portions of the principal diagram on a much reduced scale, many of the most important chemical combinations of the non-metallic elements may be represented, and to each may be added the name designating its ultimate constituents. According to the new chemical nomenclature, Fluorine, Chlorine, Bromine, and Iodine, forming the family of halogens, are represented by the four sides of the annexed figure .

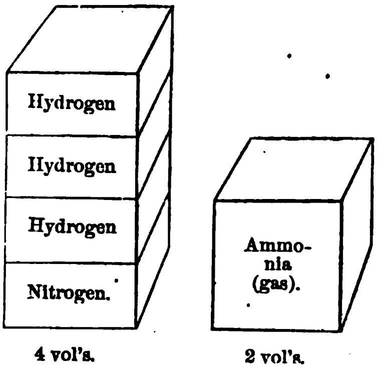
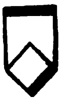
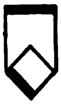
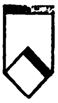
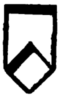
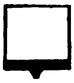
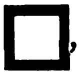


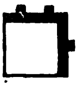
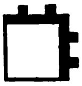
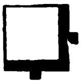
*Fig* 8..

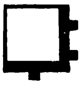
One atom of Fluorine being *af;* one of Chlorine, *ad;* one of Bromine, *ab;* one of Iodine *av;* and one of Hydrogen, *al.* I designate the acids formed by the combination of the several halogens with Hydrogen as follows (the prefix g denotes the gaseous state):

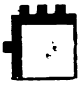
| | | |
|---|---|---|
| Hydrofluonic acid, H F. |  | *alaf.* |
| Hydrochloric acid, H Cl. |  | *galad.* |
| Hydrobromic acid, H Br. |  | *galab.* |
| Hydriodic acid, H I. |  | *galav.* |

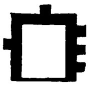
Carbon combines in such a variety of proportions with Hydrogen, Nitrogen, and Oxygen, and in many cases assuming with them the gaseous state, I represent it by a line connecting the lower ends of the lines denoting Nitrogen and Oxygen in Fig. 1. Contracting the whole, an atom of Carbon is shown by the following symbol. 

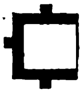
The four thick sides of this figure, thus , represent the FOUR GRAND ORGANIC ELEMENTS. Projections from each side will denote the number of atoms of each element in the symbolized chemical body. The following are symbols of some of the most common and important compounds of the non-metallic class.

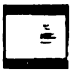
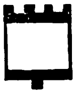
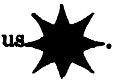
| | | | |
|---|---|---|---|
| Water | $H_2O$ |  | *elat;* (steam) *gelat.* |
| Oxygenated water | $H_2O_2$ |  | *elet* or *elt.* |
| Carbonic oxide gas | C O. |  | *garat* or *gart.* |

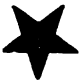
Carbonic acid gas $CO_2$  *garet.*

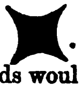
Ammonia $H_3N$  *gilan.*

Nitric acid $HNO_3$  *alanit.*

Prussic acid $HCN$  *alarn.*

The large class of hydrocarbons are represented by various projections on the following figure ; for instance, Marsh gas, or light carburetted Hydrogen $CH_4$  garol. Similar contractions of that portion of the main diagram, representing all the metals, may be used, thus .

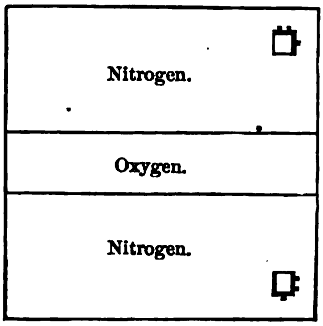
The five metals of the alkalies — viz., Lithium, Sodium, Potassium, Rubidium, and Cœsium — are designated by a star with five points .

The four metals of the alkaline earth, — viz., Barium, Strontium, Calcium, and Magnesium, — by a star with four points .

The consideration of metals and metallic compounds would open too wide a field for the present discussion.

Having treated of true chemical combination and symbolized Water and Carbonic Acid, we are prepared to speak of the mixture of gases by virtue of the law of diffusion. The following figure will convey some idea of the proportion of gases found in common Air, nearly four fifths of which is Nitrogen, and a little more than one fifth, Oxygen.

There are traces of Ammonia, Carburetted Hydrogen, and Nitric-Acid in Air, which are not represented in this figure. Ten thousand parts of common Air contain from three to six parts of Carbonic Acid. The proportion of Water in the atmosphere varies with its temperature. Every 15° C of additional heat in Air doubles its capacity for holding vapor.



Common air.

*Fig.* 9.

The diagrams now presented to the Association are intended to impress upon the mind of the student the leading characteristics of the non-metallic elements. A strong conviction that Chemistry is second to no other science in importance has impelled me to devise a method for its more general acquisition. If the symbols were firmly fixed in the memory, like the alphabet, or numerical figures, the labor of subsequent combination would be comparatively light. A groundwork, like this, thoroughly laid, will enable a student to erect in his own mind a permanent superstructure. Thus prepared, he will quickly catch the significance of every chemical compound and more readily apply the fundamental principles of the science to the experimental work of the laboratory.

## 4. A New Chemical Nomenclature.* By S. D. Tillman, of New York, N. Y.

The present seems very opportune for the introduction of a Nomenclature which will more completely methodize the Science of Chemistry. By such aid, students, who formerly deserted the study because they found themselves gradually sinking into a quagmire of incongruous names, may advance on firm ground, and view with satisfaction and profit the fair fields opened on every side by the distinguished chemists of our own time. The old nomenclature, based on the joint production of De Morveau, Lavoisier, Berthollet, and Fourcroy, published in 1787, has been frequently amended and enlarged; yet, to preserve the connection and consistency of the whole, names and classifications were retained long after they had lost their original significance. Even the broad line of distinction between acids and salts (made when oxygen acids and neutral salts only were known) gradually diminished with the successive discoveries of acid salts and the promulgation of new views by Davy and Dulong, until it is now no longer recognized by those who regard the whole class of hydracids as true salts. A fatal error was committed at the outset, in attempting to define the acids containing most and least oxygen, by adopting as terminals (rendered into English) *ic* and *ous*, and the corresponding terminals *ate* and *ite* for salts. Subsequent discoveries of higher and lower oxides involved the necessity of using, as prefixes to the words in general use, the terms *hyper* or *per* and *hypo*. Still these amendments have not obviated the difficulty, as will be seen by reference to the combinations of oxygen with sulphur. This conflict of terms was not, however, the greatest evil. The *ic* and *ous* terminals are worse than useless for expressing the degrees of oxidation, because the same terminal has a different signification in almost every series of oxides. Similar objection may be made to the use of the terminal *a* in the names of oxides; for example, Soda, now $Na_2O$; Magnesia, $MgO$; Alumina, $Al_2O_3$; and Silica, formerly $SiO_3$, by many now written $SiO_2$. Early in the present century, the words *protoxide*, *deutoxide*, etc., were used to distinguish the several degrees of oxidation having the simple ratio of combining proportions, i. e., 1: 2, 1: 3, 1: 4. No more complex ratios than 2: 3 were provided for. Many of these, and similar names applied to electro-negative elements, are often misused by distinguished authors who have adopted the atomic notation; for instance, *sesqui* to designate the combination of six atoms of a halogen with two atoms of carbon, or two of a biatomic metal.

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* Read at the meeting of the American Association for the Advancement of Science, held in the City of Buffalo, August, 1866.

The comparatively recent discovery of a great number of organic compounds, so called, required the coinage of many new names to designate radicals. Simultaneously the attempt was first made by German chemists to state definitely by prefixes the number of "equivalents" of each element in combination, which has resulted in the formation of names of a frightful length, scarcely pronounceable and seldom remembered. A complete catalogue of the chemical bodies now known would embrace several thousand terms. The novice, misled at first by common and commercial names, like "milk of lime," "sugar of lead," "cream of tartar," "oil of vitriol," and "butter of antimony," but who had advanced far enough to find no sulphur in sulphuric ether, no copper in copperas, no lead in black lead, no soda in soda water, and to be assured that "Dutch liquid" is not imported from Holland, might look with interest and wonder on the accumulated names approved by the highest authorities, and inquire whether this magnificent patchwork could be of much service as a chemical chart. To a negative reply, should be added, "Yet a substitute for the whole has been provided by the Notation."

The introduction of chemical symbols by Berzelius marks an era of progress quite as plainly as the first employment of Arabic signs and numerals in the mathematics. The notation is now frequently employed to the exclusion of chemical names, in oral as well as written communications. Its general adoption forty years ago, with the atomic signification originally attached to it by Berzelius, would have prevented the confusion of terms and signs now consequent upon the conformation of the atomic volume of gaseous elements to the one standard. Berzelius barred certain letters, to signify that one half the combining weight was the atomic weight; in other words, that the so-called "equivalent" contained two atoms. Gerhardt, on the other hand, used the same mark to denote that the combining weight must be doubled to express the atomic weight. Miller, in the third edition of his "Elements of Chemistry," designates the old notation in the usual way, and the new notation by italic capitals; while Watts, in his "Dictionary of Chemistry," still in process of publication, just reverses Miller's arrangement.

The following symbols, representing a molecule of water according to three different views, will explain what induced Berzelius, who measured volume and atomic weight on the oxygen scale, to halve the symbols representing the combining proportion of hydrogen; and why Gerhardt, who simplified measurements by making the hydrogen atom the unit of weight and bulk, was led to double the value of the symbol for oxygen, without knowing to how many other symbols the doubling process would finally be applied.

| DALTON. | BERZELIUS. | GERHARDT. |
|---|---|---|
| (2 vol.) H O (1 vol.) | $\left.\begin{matrix}\text{1 vol. H}\\ \text{1 vol. H}\end{matrix}\right\}\text{O 1 vol.}$ | $\left.\begin{matrix}\text{1 vol.}\\ \text{1 vol,}\end{matrix}\right\}\begin{matrix}\text{H}\\ \text{H}\end{matrix}\mathbf{O}\text{ 1 vol.} = \text{H}_2\,\text{O}^2$ |
| $1 + 8 = 9.$ | $.5 + .5 + 8 = 9.$ | $1 + 1 + 16 = 18.$ |

No inconsistency arises in the interpretation of these symbols; and although grave objections have been made by Herschel and Odling to the mingling of mathematical and chemical signs in chemical equations, it must be admitted that the symbol of a compound universally denotes the real body, which may be clothed with synonymes more or less expanded to suit the peculiar views of different schools.

Quite a serious derangement of the nomenclature has followed the introduction of the atomic notation. A majority of the old names have thus become inappropriate; and, chiefly for this reason, many well-known European chemists, and nearly all American chemists, still prefer to use the old system expressing combining proportions. No sweeping innovation which changes or perverts the meaning of old terms, rendering old and familiar works on chemistry comparatively worthless, and which tends to eradicate fundamental ideas, will be accepted by the present generation. How utterly futile would be the unanimous resolve of a World's Convention to change the value of our common numerals so as to represent a unit by the figure 2. Yet if they should propose to leave the old signs undisturbed, and to use new characters having the same numerical value with other important significations, the project could, perhaps, be carried into practical operation. Thus in any science it will be found most feasible to designate new views, or new structures, by new and appropriate names. This subject has commanded the attention of all advanced chemists. At the meetings of the London Chemical Society, the question has been discussed by Graham, Williamson, Miller, Brodie, Frankland, Odling, Hoffman, and other distinguished members. Gmelin's names, as modified by Watts and his compeers, seem to be received with mo favor. Williamson, Foster, and Williams have suggested valuable alterations. One would, however, be safe in predicting that, while the *ic* and *ous* system predominates, the root of the perplexity will not be reached.

The nomenclature now presented is the result of an attempt to obviate the continual embarrassment attending the prosecution of chemical studies. Failing to remember the exact composition of certain compounds, the writer resorted to mnemonical methods; and, after repeated trials, devised, in the year 1845, a system of words, generally unlike any found in dictionaries, which, with certain modifications, he has constantly employed since that time. It was originally adapted to the old classification of acids, basis, and salts, but was so arranged as to be most conveniently used in defining combinations of hydrogen, or a metal with a radical, according to the binary system. It was also early employed in explaining the now discarded Nucleus theory, as advocated by Lœwig in 1851.

Although the importance of the Typical system of classification was clearly set forth by Hunt in 1848 (*Amer. Journ. Science*, V. 265; VI. 173), not until after memorable experiments and discoveries by European chemists had demonstrated its great value, was the decision made to modify this nomenclature so as to be used with facility in expressing the new views. In attempting to take this step, however, another serious obstacle was encountered in the diversity of opinion regarding atomic weights. Kopp and Regnault had thrown new light on the subject; yet chemists of the Unitary school still agreed with the views originally advanced by Gerhardt, and recognized many metals, besides silver and those of the alkaline class, as monatomic. In 1861, however, Gibbs made it manifest that if the atomic weights of carbon, oxygen, and sulphur be taken respectively at 12, 16, and 32, the received numbers of, at least, fifty elements must be doubled (*Amer. Journ. Science*, XXXI. 246). More recently, prompted by Canizzaro, the disciples of Gerhardt have almost unanimously renounced such opinions on comparative atomic weights as are at variance with those of Berzelius.

The meaning of the new notation having thus been definitely fixed, while the nomenclature may be said to be still in the transition state, an atomic system of names, intended to supply the place *both of the notation and the old nomenclature*, is submitted for candid and critical examination. A leading consideration has been to produce a system which will assist the student in acquiring and retaining a knowledge of fundamental laws; also to provide such brief technical terms as will enable chemists generally to express their views with more conciseness.

Doubtless the most rapid advance has been made by students who have daily witnessed the operations of the laboratory. No oral description of chemical experiments could make so deep and permanent an impression. This principle of retention was well appreciated and expressed by Horace: —

> "Segnius irritant animos demissa per aurem,
> Quam quæ sunt oculis subjecta fidelibus."

Next in importance to experimental knowledge must be ranked a system of words and symbols which will convey, at sight, by means of their combinations, a clear idea of the union of the elements, without denoting, in every instance, by rational formulæ, the manner of such union. The ear, also, should be brought into service in such a system, by making the very sound of the symbols so excite the power of association as to bring before "the mind's eye" the whole series of similar and nearly related compounds. To accomplish these objects, it was necessary to construct an entirely new scheme, by providing for every well-investigated chemical body a name which should at once designate the kind and number of atoms composing it, and to a certain extent its typical and functional characteristics. This work was accomplished in a true conservative spirit, by building the new structure from old materials and upon a foundation which is the result of the combined labors of those truly great men who have devoted their lives to the advancement of chemical science.

The method of construction will be briefly explained under the following heads: —

1. The system is based on abbreviations of the universally received names of the metals, and on the chemical symbols of the metalloids, or non-metallic elements, with such modifications as were imperatively required.

2. The name of each chemical element relates, not to its mass, but only to a minimum combining proportion termed an atom, or to some multiple of it. The atom is, therefore, the unit of measurement, and the starting-point of the scale in each series of compounds.

3. The atomic name of each metal consists of two syllables, and ends with the consonant *m*.

4. The name of each of the thirteen metalloids terminates with a different consonant. Arsenic and tellurium, classed by French chemists among the metalloids, have, in this arrangement, the terminal letter common to the metals.

5. The number of atoms of any element is designated by the vowel immediately preceding its terminal consonant. The numerical power of the vowels advances with the order in which they are placed in the alphabet. *One*, *two*, *three*, *four*, and *five* are respectively expressed by *a*, *e*, *i*, *o*, and *u*, having the short or stopped sound as heard in *bat*, *bet*, *bit*, *hot*, *hut*; and *six*, *seven*, *eight*, *nine*, and *ten* by the same vowels having a long or full sound. In foreign languages, it may be best to

designate the long sound by a sign placed *over* the vowel; but in our language it is found by experience more convenient to place *e before* each of the vowels, which invariably indicates their long or full sound, as heard in the words *great*, *greet*, *sleight*, *yeoman*, *euphony*. These ten distinctive sounds may be illustrated by a single example. From one to ten atoms of iron, inclusive, have the following names: —

*Fe, Ferram*; $Fe_2$, *Ferrem*; $Fe_3$, *Ferrim*; $Fe_4$, *Ferrom*; $Fe_5$, *Ferrum*; $Fe_6$, *Ferream*; $Fe_7$, *Ferreem*; $Fe_8$, *Ferreim*; $Fe_9$, *Ferreom*; $Fe_{10}$, *Ferreum.*

The proper diphthongs are sometimes used for the even numbers between 10 and 20. These will be remembered from the fact that their value is the sum of their vowel-values, either short or long: thus, *oi* is $12 = 9 + 3$; *ou* is $14 = 9 + 5$; *au* is $16 = 6 + 10$; *oo* is $18 = 9 + 9$. The consonant *y* is 10, and used only in connection with vowels, which will express all the numbers to and including 20; *w* is 20, and, with the usual appendage, will express the numbers to and including 30. *X* is also used, and when *preceded* by a vowel, which thus has the power of an exponent, will express a progression by tens to one hundred; thus, 10, *ax*; 20, *ex*; 30, *ix*; 40, *ox*; 50, *ux*; 60, *eax*; 70, *eex*; 80, *eix*; 90, *eox*; 100, *eux*. In the same manner, these vowels preceding *qu* express the hundreds to and including one thousand, and the intermediate numbers are represented by suffixing some of the characters previously explained.

Very few chemical compounds, now known, have a composition represented by atomic numbers higher than one hundred. A large majority of the bodies of known composition do not require numbers as high as ten. The following selections will show more clearly the numerical value of each letter, and the extent to which this numerative system may be carried.

| | | | | | | |
|---|---|---|---|---|---|---|
| *a*, 1 | *ea*, 6 | *aa*, 11 | *y*, 10 | *w*, 20 | *ax*, 10 | *aqu*, 100 |
| *e*, 2 | *ee*, 7 | *oi*, 12 | *ya*, 11 | *wi*, 23 | *ex*, 20 | *equ*, 200 |
| *i*, 3 | *ei*, 8 | *ou*, 14 | *yi*, 13 | *wee*, 27 | *ix*, 30 | *eiqu*, 800 |
| *o*, 4 | *eo*, 9 | *au*, 16 | *yeo*, 19 | *weo*, 29 | *eix*, 80 | *eoquix*, 930 |
| *u*, 5 | *eu*, 10 | *oo*, 18 | *yeu*, 20 | *weu*, 30 | *eux*, 100 | *euqueix*, 1080 |

6. The following metalloids have names terminating with their well-known symbolic letters: one atom of each is here denoted.

| | | | |
|---|---|---|---|
| Fluorine, | *fluraf* or *af*; | Bromine, | *bromab* or *ab*; |
| Nitrogen, | *nitran* or *an*; | Phosphorus, | *phosap* or *ap*; |
| Carbon, | *carbac* or *ac*; | Sulphur, | *sulphas* or *as*. |

In a few instances where the symbolic letter could not be used, the terminal letter adopted may be associated with some prominent characteristic of the element. Thus *l* represents the *lightest* of substances, an atom of hydrogen is *hydral* or *al ; d* represents the *densest* of the gaseous elements, an atom of chlorine is *chlorad* or *ad; v* represents a *volatile* producing a *violet* vapor, one atom of iodine is *idav* or *av*. The atom *par excellence* is *at :* oxygen, exceeding in quantity all other elements of the earth's crust, has for the name of a single atom *oxat* or *at*. An atom of selenium is *selaz* or *az :* it bears a strong resemblance in its reactions to *as*. Boron and silicon, or silicium, like carbon, are permanent solids when isolated; their terminals may be remembered by the association of *j* and *k* in the alphabet; an atom of boron is *boraj*, or *aj*, an atom of silicon is *silak* or *ak*.

The compounds of carbon and hydrogen are so numerous that it has been found essential to provide an additional character to represent each. The letter *r* may be associated with the radiating and refracting power of carbon; and *carbar*, or *ar*, as well as *ac*, will represent an atom of carbon. As *ac* might be mistaken for *ak*, in radical compounds, the carbon component is denoted generally by *r*.

The only case in which it has been found advantageous to use one letter to designate two atoms is that of *h* for two atoms of hydrogen or *hydrel*, thus preserving the ratio of the old combining numbers, $C_2H_2O_2$ being *cht*. It will be noted that *ach* corresponds with $C_2H_2$ in the old notation, and with $CH_2$ in the new: it is the key to a series of radicals, i. e., methyl, $CH_3$ is *achal ;* ethyl, $C_2H_5$; *echal*.

7. Metalloid terminal syllables express as much as the full name, and are used as suffixes to names of metallic atoms to denote a metallic compound; for example, the protoxide of iron is *ferramat*, which indicates very clearly that one atom of iron is united with one atom of oxygen. A combination of metalloid syllables represents a non-metallic compound. In numerous cases, the number of syllables forming such a word is less than the number of different elements in the compound, because two or more terminal characters may be united, and the vowel or diphthong preceding the whole will be applicable to each; for instance, *elt* $= H_2O_2$ is a molecule of oxygenated water, or peroxide of hydrogen; *arn* $=$ CN is an atom of cyanogen, and *ant* $=$ NO is a molecule of binoxide of nitrogen. It will be seen presently that the names of salts containing one atom of a metal are sometimes slightly abbreviated by omitting the *a* which should precede *m ;* also

that *m*, with a vowel preceding it, is applied to multiples of any radical playing the part of a metal.

The following table embraces all the chemical elements known with certainty, and their atomic numbers corresponding with the systems of Berzelius and Gerhardt, to each of which the new names are equally applicable. The highest and lowest known oxides of each element are also added. Names included in brackets are hydrates containing three elements. In twelve cases, where the same metal is known by two names, each name has been adapted to the new system; the first name in each couplet is derived from that recognized by chemists of every nation.

| SYMBOLS. | At. wt. al.=5. | At. wt. al.=1. | Name of one atom. | Name of a molecule (2 at) | Name of lowest oxide. | Name of highest oxide. |
|---|---|---|---|---|---|---|
| H | .5 | 1. | Hydral | Hydrel | $H_2O$ *Hydrelat* | $H_2O_2$ *Hydrelt* |
| N | 7. | 14. | Nitran | Nitren | $N_2O$ *Nitrenat* | $N_2O_5$ *Nitrenut* |
| O | 8. | 16. | Oxat | Oxet | | |
| C | 6. | 12. | Carbac | Carbec | | |
| " | " | " | Carbar | Carber | $CO$ *Carbart* | $CO_2$ *Carbaret* |
| Si | 14. | 28. | Silak | Silek | | $SO_2$ *Silaket* |
| B | 5.45 | 10.9 | Boraj | Borej | | $B_2O_3$ *Borejit* |
| P | 15.5 | 31. | Phosap | Phosep | $PO$ *Phosapt* | $P_2O_5$ *Phoseput* |
| S | 16. | 32. | Sulphas | Sulphes | $SO_2$ *Sulphaset* | $SO_3$ *Sulphasit* |
| Se | 39.75 | 79.5 | Selaz | Selez | $SeO_2$ *Selazet* | *(Alazot)* |
| F | 9.5 | 19. | Fluraf | Fluref | | |
| Cl | 17.73 | 35.46 | Chlorad | Chlored | $Cl_2O$ *Chloredat* | *(Aladot)* |
| Br | 40. | 80. | Bromab | Bromeb | | *(Alabit)* |
| I | 63.5 | 127. | Idav | Idev | $HIO$ *(Alavat)* | $I_2O_7$ *Ideveet* |
| METALS. | | | | | | |
| Cs | 66.5 | 133. | Cœsam | Cœsem | $Cs_2O$ *Cæsemat* | *(Cæsamalt)* |
| Rb | 42.5 | 85. | Rubam | Rubem | *Rubemat* | *(Rubamalt)* |
| K | 19.5 | 39. | Kalam, *or* | Kalem | *Kalemat* | *(Kalamalt)* |
| " | " | " | Potam | Potem | *Potemat* | *(Potamalt)* |
| Na | 11.5 | 23. | Natam, *or* | Natem | *Natemat* | *(Natamalt)* |
| " | " | " | Sodam | Sodem | *Sodemat* | *(Sodamalt)* |
| L | 3.5 | 7. | Litham | Lithem | *Lithemat* | *(Lithamalt)* |
| Ba | 68.5 | 137. | Baram | Barem | $BaO$ *Baramat* | *Baramet* |
| Sr | 43.8 | 87.6 | Stronam | Stronem | *Stronamat* | *Stronamet* |
| Ca | 20. | 40. | Calcam | Calcem | *Calcamat* | |
| Mg | 12.15 | 24.3 | Magam | Magem | *Magamat* | |
| Al | 13.7 | 27.4 | Alam | Alem | *Alemit* | |
| G | 4.7 | 9.4 | Glucam | Glucem | *Glucemit* | |
| Zr | 44.75 | 89.5 | Ziram | Zirem | *Ziremit* | |
| Th | 119. | 238. | Thoram | Thorem | *Thoramat* | |
| Yt | 30.85 | 61.7 | Yttram | Yttrem | *Yttramat* | |
| E | 56.30 | 112.6 | Erbam | Erbem | *Erbamat* | |
| Tb | | | Terbam | Terbem | *Terbamat ?* | |
| Ce | 46. | 92. | Ceram | Cerem | *Ceramat* | *Ceremet* |
| La | 46.47 | 92.94 | Lanam | Lanem | *Lanamat* | |
| Di | 48. | 96. | Didam | Didem | *Didamat* | |
| Zn | 32.75 | 62.5 | Zinam | Zinem | *Zinamat* | *(Zinamelt)* |
| In | 35.91 | 71.82 | Indam | Indem | *Indamat* | |

TABLE. — (*Continued.*)

| SYMBOLS. | At. wt. al. = 5. | At. wt. al. = 1. | Name of one atom. | Name of molecule (2 at) | Name of lowest oxide. | Name of highest oxide. |
|---|---|---|---|---|---|---|
| Cd | 56. | 112. | Cadam | Cadem | *Cadamat* | |
| Co | 29.50 | 59. | Cobam | Cobem | *Cobamat* | *Cobemit* |
| Ni | 29 87 | 58.74 | Nikam | Nikem | *Nikamat* | *Nikemit* |
| U | 60. | 120. | Uram | Urem | *Uramat* | *Uremit* |
| Fe | 28. | 56. | Ferram, *or* | Ferrem | *Ferramat* | *Ferremit* |
| “ | “ | “ | Iram | Irem | *Iramat* | *Iremit* |
| Cr | 26.27 | 52.54 | Chram | Chrem | (*Chramalt*) | *Chramit* |
| Mn | 27.50 | 55. | Manam | Manem | *Manamat* | *Manamet* |
| Sn | 59. | 118. | Stanam *or* | Stanem | *Stanamat* | *Stanamet* |
| “ | “ | “ | Tinam | Tinem | *Tinamat* | *Tinamet* |
| Ti | 25 | 50. | Titam | Titem | *Titamat* | *Titamet* |
| Nb | 49.13 | 98.26 | Nobam *or* | Nobem | *Nobemit* | *Nobamet* |
| Cl | “ | “ | Colam | Colem | *Colemit* | *Colamet* |
| Ta | 91. ? | 182. ? | Tanam | Tanem | *Tanemit* | *Tanamet* |
| Mo | 48. | 96. | Molam | Molem | *Molamat* | *Molamit* |
| V | 68.46 | 136.92 | Vanam | Vanem | *Vanamat* | *Vanemit* |
| W | 92. | 184. | Walam | Wolem | *Wolamat* | *Wolamit* |
| “ | “ | “ | Tunam | Tunem | *Tunamat* | *Tunamit* |
| As | 37.5 | 75. | Arsam | Arsem | *Arsamat* | *Arsamut* |
| Sb | 60.15 | 120.3 | Stibam *or* | Stibem | *Stibamat* | *Stibamut* |
| “ | “ | “ | Antam | Antem | *Antamat* | *Antamut* |
| Bi | 105. | 210. | Bisam | Bisem | *Bisamat* | *Bisamot* |
| Cu | 31.75 | 62.5 | Cupam *or* | Cupem | $C_2O$ *Cupemat* | *Cupamet* |
| “ | “ | “ | Coppam | Coppem | *Coppemat* | *Coppamet* |
| Pb | 103.5 | 207. | Plubam *or* | Plubem | *Plubemat* | *Plubamet* |
| “ | “ | “ | Leadam | Leadem | *Leadamat* | *Leadamet* |
| Tl | 101.75 | 203.5 | Thallam | Thallem | | *Thallamit* |
| Te | 64.5 | 129. | Tellam | Tellem | *Tellamat* | *Tellamit* |
| Hg | 100. | 200. | Hygam *or* | Hygem | *Hygemat* | *Hygamat* |
| “ | “ | “ | Mercam | Mercem | *Mercemat* | *Mercamat* |
| Ag | 54. | 108. | Argam *or* | Argem | *Argemat* | *Argamet* |
| “ | “ | “ | Silvam | Silvem | *Silvemat* | *Silvamet* |
| Au | 98.33 | 196.66 | Auram *or* | Aurem | *Auremat* | *Auremit* |
| “ | “ | “ | Goldam | Goldem | *Goldemat* | *Goldemit* |
| Pt | 98.56 | 199.12 | Platam | Platem | *Platamat* | *Platamet* |
| Pd | 53.24 | 106.48 | Pallam | Pallem | *Pallemat* | *Pallamet* |
| Ro | 52.16 | 104.32 | Rhodam | Rhodem | *Rhodamat* | *Rhodemit* |
| Ru | 52 11 | 104.22 | Rutham | Ruthem | *Ruthamat* | *Ruthamet* |
| Os | 99.41 | 198.82 | Osman | Osmen | *Osmamat* | *Osmamot* |
| Ir | 98.56 | 197.12 | Irdam | Irdem | *Irdamat* | *Irdamet* |

As a whole, the old symbols, representing combining proportions, are applicable to neither column of atomic weights. Fewer changes are required by adopting the weights of the first column; yet the advantages derived from estimating H = 1 are so obvious, that the symbols used in the remainder of the paper will represent the numbers in the second column. Those having the old value will be denoted by the usual letters, and symbols of doubled value by full-faced type.

A complete series of known oxides of several metals (excluding hydrates) are here presented, for the purpose of comparing the old and new system as to brevity and precision.

1. Protoxide of iron (Ferrous oxide), $FeO$ : *Ferramat.*
Sesquioxide or Peroxide of iron (Ferric oxide), $Fe_2O_3$ : *Ferremit.*

INTERMEDIATE OXIDES.

Black or Magnetic oxide of iron (Ferroso-ferric oxide), $Fe_3O_4$ : *Ferrimat.*
A nameless oxide of iron (auct. BERTHIER & GLASSON),
$4\ FeO\ F_2O = Fe_6O_7$ : *Ferreameet.*
Scale oxide of iron (inner layer), $6\ Fe\ O\ Fe_2O_3 = Fe_8O_9$ : *Ferreimeat.*

The name of the latter, expressing the supposed rational formula, is *Ferreameat - Ferremit.*

2. Protoxide of manganese (Manganous oxide), $MnO$ : *Manamat.*
Red oxide of manganese (Manganoso-manganic oxide), $Mn_3O_4$ : *Manimat.*
Sesquioxide of manganese (Manganic oxide), $Mn_2O_3$ : *Manemit.*
Peroxide of manganese (Dioxide of **M.**), $MnO_2$ : *Manamet.*

8. The Chromium atom, properly *Chromam*, may be contracted to *Chram;* which is especially convenient in denoting chromates.
Protoxide of Chromium (Chromous oxide), $CrO$ : *Chramat.*
Magnetic oxide of chrome (Chromoso-chromic oxide), $Cr_3O_4$ : *Chrimat.*
Sesquioxide of chromium (Chromic oxide), $Cr_2O_2$ : *Chremit.*
Monochromate of sesquioxide of chromium, $Cr_3O_6$ : *Chrimeat.*
Bichromate of sesquioxide of chromium, $Cr_4O_9$ : *Chromeat.*
Neutral chromate of sesquioxide of chromium, $Cr_5\ O_{12}$ : *Chrumoit.*
Acid chromate of sesquioxide of chromium, $Cr_6O_{15}$ : *Chreamyut.*
Chromic acid. $CrO_3$ *Chramit.*

Including hydrates, the oxides of metals, metalloids, and organic radicals now known may be estimated in round numbers at 400. The following oxides of a halogen are adduced to show the inadequacy of the old nomenclature in defining the higher combining ratios of only two elements : —

Iodic anhydride, $I_2O_5$, *evut;* Hypoiodic acid, $I_2O_4$, *evot;* Intermediate oxide (auct. KÆMMERER), $I_6O_{13}$, *eavyit;* Subhypoiodic acid (auct. MILLON), $I_{10}O_{19}$, *euvyeot.*

A few brief observations will perhaps aid in apprehending the purport of numerous new combinations, illustrating the doctrine of types and substitutions.

1. An atom has a definite maximum power of holding other atoms in chemical union. The normal quantivalence or highest saturating capacity of an atom, that is, its so-called atomicity, decreases as it is duplicated and condensed.

2. *Chlorad* is ranked in the class of elements having the lowest saturating power: therefore *ad* may be taken as the unit of measurement, and thus words already in use in this connection are made peculiarly appropriate; for example, *hydral* is a monad, *oxat* is a dyad *nitran* is a triad (often a pentad), *carbar* is a tetrad, *phosap* is a pentad and often a triad. *Carber*, *ferrem*, *alem*, *chromem*, and other DOUBLE-ATOMS forming sesquioxides, behave like hexads, while *manam* appears to be a heptad. *Arsam*, *bisam*, and *stibam* are either triads or pentads.

3. A molecule is a complete chemical structure, capable of existing in a separate state: that part of it which can unite with various monad radicals — known as the residue or remainder of a molecule — being regarded as a broken structure or imperfect body may be called a *torso*.

4. The atomicity of a torso, or of a radical containing one atom of an element united to one or more atoms of another element, is equal to the difference between the normal saturating power of its components. The following are examples: —

COMPOUND MONADS: Ammonium, $H_4N'''$ = *olan* or *ilanal'*; Hydroxyl, $H'O''$ = *alt'*;
Amidogen, $H_2N'''$ = *elan'*; Nitric oxide, $N'''O_2''$ = *anet'*;
Cyanogen, $C^{iv}N'''$ = *arn'*.

COMPOUND DYADS: Carbonyl (Carbonic oxide), $C^{iv}O''$ = *arat* or *art''*:
Monamine, $HN'''$ = *alan''*; Methylene, $C^{iv}H_2$ = *arel* or *ach''*.

COMPOUND TRIADS: Formene, $C_{iv}H$ = *arl'''*; Phospil, $P^{v}O''$ = *apt'''*.

5. The researches of Kekulé have shown that the same number of carbon and hydrogen atoms, having different saturating powers, are related to different hydrocarbon series; and the equivalence of such isomers may be determined by the number of hydrogen atoms they contain. For example, glyceryl, $C_3H_5$ (*echarl'''*), having three less hydrogen atoms than the hydride of propyl (*ichel*), $C_3H_8$, is a triad; while allyl, $C_3H_5$ (*arechal'*), having one atom of hydrogen less than propylene, $C_3H_6$ (*irlil'*), is a monad. Thus also to the series of highest saturation of carbon belongs acetylene, $C_2H_2$ (*erel* or *erl*$^{iv}$); and having four atoms of hydrogen less than the hydride of ethyl, $C_2H_6$ (*echel*), it is a tetrad. If two atoms of the monad bromine be added, the saturating power of the compound will be diminished two degrees; therefore the bibromide of acetylene, $C_2H_2Br_2$ (*erleb*) is a dyad. The

late brilliant elucidations of atomicity by Wurtz have thrown light on many points, to which reference cannot now be made.

6. A complex hydrocarbon monad radical may be regarded as the combination of a monad with an even number of radicals or torsoes *in equilibrio*. The following are examples: —

Acetyl = $(CO'' \, CH_2'') + H =$ *artachal'*.
Propyl = $(CH_2'' \, CH_2'') + CH_3' =$ *ichal'*.
Butyl = $(CH_2'' \, CH_2'' \, CH_2'' \, CH_2'') + H =$ *ochal'*.

7. Gerhardt classified chemical compounds under four types, two of which, the hydrogen and the hydrochloric-acid types, are molecules consisting of two monads: one molecule should therefore be taken as the primal type, and the other as a sub-type. The use of only three types would, at first sight, be commended for its simplicity; yet the vast diversity of Nature's combinations involves the necessity of many multiples, and the formation of mixed types as proposed by Odling, in which the saturating power of the several parts is distinguished by the signs used in this paper. Valid arguments may be urged in favor of using at least five types, in each of which one-half the saturating power expended to form the molecule is derived from a single atom. The atom-holding power of one-half being balanced by that of the other half of each molecule, it is proposed to distinguish each type by the name expressing the equivalence of one-half of it. The following will show the value of the new characters in typical expressions: —

| MONAD TYPE. | DYAD TYPE. | TRIAD TYPE. | TETRAD TYPE. | PENTAD TYPE. |
|---|---|---|---|---|
| Hydrochloric acid. | Water. | Ammonia. | Marsh gas. | Chloride of phosphorus. |
| $al \} ad.$ | $\left.\begin{matrix} al \\ al \end{matrix}\right\} at.$ | $\left.\begin{matrix} al \\ al \\ al \end{matrix}\right\} an.$ | $\left.\begin{matrix} al \\ al \\ al \\ al \end{matrix}\right\} ar.$ | $\left.\begin{matrix} al \\ al \\ al \\ al \\ al \end{matrix}\right\} ap.$ |

In representing the most important bodies formed by the replacement of one or more atoms of hydrogen by one or more monad radicals, the change consists, as will presently be shown, simply in substituting for *al* the name of a radical ending with *al*. The different views of chemists respecting the typical form of the same body may be distinctly illustrated by the new characters; take, for example, acetic acid, $C_4 \, H_4 \, O_4 = C_2 \, H_4 \, O_2$. Kolbe's carbonic-acid type, being essentially the same as the water type, is omitted, and the so-called radical type is added in the following table: —

| EMPIRICAL. | GERHARDT. | DEBUS. | FRANKLAND & DUPPA. |
|---|---|---|---|
| *olert*<br>or<br>*echet.* | $\left.\begin{matrix}al\\artachal\end{matrix}\right\}at.$ | $ar\left\{\begin{matrix}achal'\\at''\\alt'.\end{matrix}\right.$ | $ar\left\{\begin{matrix}al\\al\\al\end{matrix}\right.$<br>$ar\left\{\begin{matrix}at''\\alt'.\end{matrix}\right.$ |

The empirical name *echet* is the second in a series of which *achet* (formic acid) is the first; *ichet* (propylic acid), the third; *ochet* (butylic acid), the fourth; *uchet* (amylic acid), the fifth; and so on to the highest or most condensed molecule *weuchet* (melissic acid), represented in the old notation by HO $C_{60}H_{59}O_3$, and in the new by $C_{30}H_{60}O_2$. These short and simple names, formed by changes in the first syllable, represent these acids as the result of successive additions of *ach* $(CH_2)$; but they cannot be made available in illustrating the changes which occur when an atom of hydrogen is replaced by a metal or a radical. The other empirical name may be used by those who prefer to express no opinion as to the actual constitution of the acid. To carry out this view, the replaceable atom of hydrogen in the acid may form the first syllable, and the remaining syllables will be the terminal of the acetates formed by monad metals, e. g., acetic acid, *alilert;* acetate of potash, *Kalmilert.* The terminal syllables must be doubled in value, to denote acetates of dyad metals; for example, acetate of lead, *Plubmealort.* In consideration of the existence of numerous important bodies, into the construction of which an acid-forming radical of this series enters, it has been found most desirable to designate the acids by names which bring the radical more clearly to view. Preference is therefore given to those which are readily resolved into the water or dyad type; thus, acetic acid, as *alartachalt* or *lartachalt,* is easily separated into syllables which reveal its typical structure [*al-artachal*]*at.* When *al* is replaced by a monad metal, the typical form is still apparent [*am-artachal*]*at.* An atom of a dyad metal replaces the hydrogen atom in two molecules of acid: therefore the torso *artachalt* is doubled, which is indicated by the suffix *e* having the sound of *eh,* thus, *artachalte.* In the sesquiacetates, the double-torso *artachalte* is trebled, and indicated by the suffix *ea* = 6; for example, one of the acetates of alumina = $Al^2C_{12}H_{18}O_{12}$, is *Alemartachaltea.*

All the types previously enumerated may be regarded as subtypes, embraced in a regular series of types consisting of condensed molecules of hydrogen, according to the suggestion originally made by Hunt. In the following table, containing several new types, the condensed hydrogen molecules are connected with the types of substantially the same significance by the mathematical symbol of equivalency. Atoms in brackets in the first series are replaced by other atoms in the second.

| RATIOS. | HYDROGEN MOLECULES. | | OLD NAMES. | NEW NAMES. |
|---|---|---|---|---|
| 1 : | I al-[al] | $\asymp HCl$, | Hydrochloric acid | = *alad.* |
| 2 : | I el-[el] | $\asymp H_2O$, | Water | = *elat.* |
| 3 : | I il-[il] | $\asymp H_3N$, | Ammonia | = *ilan.* |
| I : | 4 [ol]-ol | $\asymp CH_4$, | Marsh gas | = *arol.* |
| I : | 5 [ul]-ul | $\asymp PCl_5$, | Pentachloride of phosphorus | = *apud.* |
| I : | 6 [eal]-eal | $\asymp CrF_6$, | Perfluoride of chromium | = *chrameaf.* |
| I : | 7 [eel]-eel | $\asymp MnCl_7$, | Perchloride of manganese | = *manameed.* |
| I : | 4 [ol]-ol | $\asymp CH_3H$, | Hydride of methyl | (*achal-al*) = *achel.* |
| II : | 6 [eal]-eal | $\asymp C_2H_5H$, | Hydride of ethyl | (*echal-al*) = *echel.* |
| III : | 8 [eil]-eil | $\asymp C_3H_7H$, | Hydride of propyl | (*ichal-al*) = *ichel.* |
| IV : | 10 [eul]-eul | $\asymp C_4H_9H$, | Hydride of butyl | (*ochal-al*) = *ochel.* |
| V : | 12 [yel]-yel | $\asymp C_5H_{11}H$, | Hydride of amyl | (*uchal-al*) = *uchel.* |
| VI : | 14 [yol]-yol | $\asymp C_6H_{13}H$, | Hydride of caproyl | (*euchal-al*) = *euchel.* |
| VII : | 16 [yeal]-yeal | $\asymp C_7H_{15}H$, | Hydride of œnanthyl | (*eechal-al*) = *eechel.* |
| VIII : | 18 [yeil]-yeil | $\asymp C_8H_{17}H$, | Hydride of capryl | (*eichal-al*) = *eichel.* |
| XII : | 26 [weal]-weal | $\asymp C_{12}H_{25}H$, | Hydride of lauryl | (*oichal-al*) = *oichel.* |
| XVI : | 34 [ixol]-ixol | $\asymp C_{16}H_{33}H$, | Hydride of cetyl | (*auchal-al*) = *auchel.* |
| XXVII : | 56 [uxeal]-uxeal | $\asymp C_{27}H_{55}H$, | Hydride of ceryl | (*weechal-al*) = *weechel.* |
| XXX : | 62 [eaxel]-eaxel | $\asymp C_{30}H_{61}H$, | Hydride of melissyl | (*weuchal-al*) = *weuchel.* |

It is evident that the so-called "atomicity" does not prevent the union of atoms in a regular progressive series of ratios. In such cases the atom-holding energy has different degrees of development as the result of the reflex influence of combination. Apparent abnormal action, for instance, in the case of $I_2O_7$, *eveet,* may be accounted for by supposing an even number of atoms of oxygen, $O_6$, in alternately opposite polar conditions, to be united with $I_2O$. When mercury and chlorine form calomel, *mercamad,* the anomaly is explained by the fact that the volume of the compound corresponds with that of a molecule of hydrogen; thus, in this, as well as the case of the hydride of copper, *cupamal,* a dyad metal plays the part of a monad.

The new names of acids and salts, of simple as well as intricate constructions, are so framed that they may readily be resolved into syllables expressing their typical relations. This is accomplished by making the replaceable hydrogen of an acid the prefix which determines the type on which the compound is constructed, as explained previously in speaking of the acetic acid. The typical name of an acid or salt embraces, in fact, three terms; the first consists of the replaceable hydrogen, the second is another portion of the compound of equal equivalence to the first, and the remaining oxygen atoms will constitute a third term having the atomic equivalence of the first and second terms combined. In chemical reactions, the second and third terms generally remain unchanged, and may therefore be included as one name, and the whole name may be said to represent the combination of a radical with a torso. Examples:—

| | | | |
|---|---|---|---|
| Nitric acid, | "monatomic" | $[al'\text{-}anct']at''$ | = *alanit.* |
| Sulphuric acid, | "biatomic" | $[el''\text{-}aset'']et^{iv}$ | = *elasot.* |
| Phosphoric acid, | "triatomic" | $[il'''\text{-}apt''']it^{vi}$ | = *ilapot.* |

The halogens are powerful electro-negative elements. Having the best structural adaptability, as monads, they are found among the components of many bodies. Those well investigated may be estimated in round numbers thus: Chlorides, 750; iodides, 320; fluorides, 160; bromides, 150; to which may be added another class of very similar structure: the cyanides, 220; total, 1630. In this estimate, several hundred chlorhydrates, bromhydrates and iodhydrates are not included. Their new names will be so readily understood, it is only essential to present such examples as will explain the changes required by the atomic notation and the typical classification:—

MONAD TYPE.

| | | | | |
|---|---|---|---|---|
| Hydrofluoric acid, | HF, | *alaf:* | Fluoride of thallium, | *Thalamaf.* |
| Hydrochloric acid, | HCl, | *alad:* | Chloride of sodium, | *Sodamad.* |
| Hydrobromic acid, | HBr, | *alab:* | Bromide of ammonium, | *Olanab.* |
| Hydriodic acid, | HI, | *alav:* | Iodide of potassium, | *Potamav.* |
| Hydrocyanic acid, | HCy, | *alarn:* | Cyanide of silver. | *Argamarn.* |

DYAD TYPE.

| | | | |
|---|---|---|---|
| Fluor spar, | *Calcamef.* | Corrosive sublimate, | *Mercamed.* |
| Chloride of thorium, | *Thoramed.* | Bromide of cadmium, | *Cadameb.* |
| Bromide of yttrium, | *Yttrameb.* | Iodide of zinc, | *Zinamev.* |
| Cyanide of iron, | *Ferramern.* | Cyanide of magnesium, | *Magamern.* |

TRIAD TYPE.

| | | | |
|---|---|---|---|
| Fluoride of arsenic, | *Arsamif.* | Chloride of antimony, | *Stibamid.* |
| Bromide of gold, | *Auramib.* | Iodide of bismuth, | *Bisamiv.* |
| Bromide of nitrogen, | *Anib.* | Solid chloride of cyanogen, | *Irnid.* |
| Fluoride of boron, | *Ajif.* | Bromide of boron, | *Ajib.* |

### TETRAD TYPE.

| | | | |
|---|---|---|---|
| Perfluoride of titanium, | *Titamof.* | Perchloride of tin, | *Stannamod.* |
| Perbromide of tellurium, | *Tellamob.* | Periodide of platinum, | *Platamov.* |
| Perchloride of tantalium, | *Tanamod.* | Percyanide of palladium, | *Pallamorn.* |

### PENTAD TYPE.

| | | | |
|---|---|---|---|
| Pentachloride of antimony, | *Stibamud.* | Quinquiodide of arsenic ? | *Arsamuv.* |
| Pentabromide of phosphorus, | *apud.* | Quinquebromide of iodine, | *avub.* |
| Quinquiodide of tetrethyl-ammonium, | *echalom-anuv.* | | |

### HEXAD TYPE.

| | | | |
|---|---|---|---|
| Perfluoride of vanadium, | *Vanameaf.* | Periodide of tellurium, | *Tellameav.* |
| Perchloride of molybdenum, | *Molamead.* | Perfluoride of chromium, | *Chrameaf.* |
| Perbromide of tungsten, | *Wolameab.* | Perfluoride of silicon, | *Akeaf.* |
| Perfluoride of selenium, | *Azeaf.* | Perbromide of silicon, | *Akeab.* |

### SUBTYPE, OR RADICAL TYPE.

| | | | |
|---|---|---|---|
| Chloride of aluminium, | *Alemeud.* | Perchloride of iron, | *Ferremead.* |
| Perchloride of cerium, | *Ceremead.* | Perfluoride of ruthenium, | *Ruthemeaf.* |
| Perfluoride of glucinum, | *Glucemeaf.* | Chloride of osmium, | *Osemead.* |

### HEPTAD TYPE.

| | | | |
|---|---|---|---|
| Perchloride of manganese, | *Manameed.* | Perfluoride of manganese, | *Manameef.* |

The sulphides, selenides, and tellurides resemble in constitution the oxides. From nearly 300 well-known sulphides, the following are selected: —

| | | | |
|---|---|---|---|
| Sulphuretted hydrogen, | *elas.* | Persulphide of hydrogen, | *elus.* |
| Bisulphide of carbon, | *ares.* | Bisulphide of nitrogen, | *enes.* |
| Monosulphide of potassium (old name) KS = $K_2S$. | | | *Kalemas.* |
| Monosulphide of mercury (cinnabar). | | | *Meremas* or *Hygamas.* |
| Bisulphide of iron (pyrites), | | | *Ferrames.* |
| Tersulphide of gold, | | | *Auramis.* |
| Quadrisulphide of molybdenum, | | | *Molamos.* |
| Pentasulphide of antimony, | | | *Antamus* or *Stibamus.* |
| Sesquisulphide of rhodium, | | | *Rhodemis.* |
| A magnetic iron pyrites (with no systematic name), $Fe_3S_4$, | | | *Ferrimos.* |
| Another variety of pyrites, $Fe_7S_8$ (no name), | | | *Ferreemeis.* |

The next table contains the known combinations of oxygen with sulphur, forming oxides and acids: —

| | | | |
|---|---|---|---|
| Sulphurous anhydride, | *aset.* | Hyposulphurous acid, | *elesit.* |
| Sulphurous acid, | *elasit.* | Hyposulphuric acid, | *eleseat.* |
| Sulphuric anhydride, | *asit.* | Trithionic acid, | *eliseat.* |
| Nordhausen sulphuric acid, | *aleseat.* | Tetrathionic acid, | *eloseat.* |
| Sulphuric acid (oil of vitriol), | *elasot.* | Pentathionic acid, | *eluseat.* |
| Trithionic anhydride, | *isut.* | | |

In these acids or salts of hydrogen, *el* may be replaced by a dyad metal, or, atom for atom, by a monad metal, thus forming metallic salts.

From nearly 700 known varieties of sulphates, the following are selected: —

| | | | |
|---|---|---|---|
| Sulphate of protoxide of iron, | *fermasot.* | Sulphate of copper, | *cupmasot.* |
| Sulphate of magnesia, | *magmasot.* | Sulphate of baryta, | *barmasot.* |
| Sulphate of soda, | *natemasot.* | Sulphate of lithium, | *lithemasot.* |

Of nearly 200 sulphites, only two will be mentioned: —

| | | | |
|---|---|---|---|
| Sulphate of cerium, | *cermasit.* | Sulphite of potash, | *kalemasit.* |

From nearly 200 carbonates, only the following are selected: —

| | | | |
|---|---|---|---|
| Carbonate of lime, | *calcmarit.* | Carbonate of magnesia, | *magmarit.* |
| Carbonate of soda, | *natemarit.* | Bicarbonate of soda, | *natmalarit.* |

Of 300 oxalates, only two are here cited: —

| | | | |
|---|---|---|---|
| Oxalate of baryta, | *barmerot.* | Salt of sorrel, | *potmalerot.* |

From 100 varieties of silicates, only the following will be noted: —

Silicate of alumina (sillimanite), $Al_2SO_5$, *alemakut.*
Silicate of alumina (kaolin), $Al_2S_2O_7$, *alemekeet.*
Silicate of potash, *potemakit.* Silicate of lime, *calcmakit.*
Silicate of magnesia, *magmakit.*

From about 50 nitrites, only two are presented: —

| | | | |
|---|---|---|---|
| Nitrite of soda, | *sodmanet.* | Nitrite of strontia, | *stronmenot.* |

From 400 varieties of nitrates, the following are selected: —

Nitrate of potash, *kalmanit.* Nitrate of silver, *argmanit.*
Nitrate of uranium, *urmeneat.* Protonitrate of iron, *fermeneat.*
Nitrate of sesquioxide of iron, $Fe_2O_3\ N_6O_{15}$, *ferremeanoot.*

Of 370 phosphates, only the following: —

Tribasicphosphate of lime (in bones), $Ca_3P_2O_8$, *calcimepeit.*
Bibasic phosphate of lime, $Ca_2HP_2O_8$. *calcemalepeit.*
Acid or Superphosphate of lime, $CaH_4P_2O_8$, *calcmolepeit.*

From 90 sulphocyanides, only one will be mentioned: —

Sulphocyanide of mercury, $HyCy_2S$, *mercmernas.*

A few other terminals of salts may be thus briefly enumerated, a monad metal being denoted by *am* : —

| | | | |
|---|---|---|---|
| 210 | tartrates, | *em-orleat.* | 40 chlorates have the terminal *amadit.* |
| 60 | malates, | *em-orlut.* | 60 iodates have the terminal *amavib.* |
| 100 | citrates, | *im-earuleet.* | 380 chlorhydrates have the prefix *ald.* |
| 120 | chromates, | *em-chramot.* | 50 bromhydrates have the prefix *alb.* |
| 270 | chloroplatinates, | *am-platamid.* | 100 iodhydrates have the prefix *alv.* |

Ferro-cyanhydrates or -cyanides, *em-ferramirn.*
Ferri-cyanhydrates or -cyanides, *im-ferremearn.*

The monad radicals forming the largest class of alcohols, and the corresponding monad radicals of the fatty-acid series, are in the next table placed side by side : —

| ALCOHOL-FORMING RADICALS. | | | ACID-FORMING RADICALS. | | |
|---|---|---|---|---|---|
| Methyl, | $CH_3 = CH_2H$, | *achal.* | Formyl, | $COH$, | *artal.* |
| Ethyl, | $C_2H_5 = C_2H_4H$, | *echal.* | Acetyl, | $COCH_3$, | *artachal.* |
| Propyl, | $C_3H_7 = C_3H_6H$, | *ichal.* | Propionyl, | $COC_2H_5$, | *artechal.* |
| Butyl, | $C_4H_9, = C_4H_8H$, | *ochal.* | Butyryl, | $COC_3H_7$, | *artichal.* |
| Amyl, | $C_5H_{11} = C_5H_{10}H$, | *uchal.* | Valeryl, | $COC_4H_9$, | *artochal.* |
| Caproyl, | $C_6H_{13} = C_6H_{12}H$, | *eachal.* | Caproylyl, | $COC_5H_{11}$, | *artuchal.* |
| Œnanthyl, | $C_7H_{15} = C_7H_{14}H$, | *eechal.* | Œnanthoyl, | $COC_6H_{13}$, | *arteachal.* |
| Capryl, | $C_8H_{17} = C_8H_{16}H$, | *eichal.* | Caprylyl, | $COC_7H_{15}$, | *arteechal.* |
| | Wanting. | | Pelargonyl, | $COC_8H_{17}$, | *arteichal.* |
| | “ | | Rutilyl, | $COC_9H_{19}$, | *arteochal.* |
| | “ | | Enodilyl, | $COC_{10}H_{21}$, | *arteuchal.* |
| Lauryl, | $C_{12}H_{25} = C_{12}H_{24}H$, | *yechal.* | Laurilyl, | $COC_{11}H_{23}$, | *artaxachal.* |
| | Wanting. | | Coccinyl, | $COC_{12}A_{25}$, | *artaxechal.* |
| | “ | | Meristyl, | $COC_{13}H_{27}$, | *artaxichal.* |
| | “ | | Benyl, | $COC_{14}H_{29}$, | *artaxochal.* |
| Cetyl, | $C_{16}H_{33} = C_{16}H_{32}H$, | *yeachal.* | Palmityl, | $COC_{15}H_{31}$, | *artaxuchal.* |
| | Wanting. | | Margaryl, | $COC_{16}H_{33}$, | *artaxeachal.* |
| | “ | | Stearyl, | $COC_{17}H_{35}$, | *artaxeechal.* |
| | “ | | Balenyl, | $COC_{18}H_{37}$, | *artaxeichal.* |
| | “ | | Arachidyl, | $COC_{19}H_{39}$, | *artaxeochal.* |
| | “ | | Nardyl, | $COC_{20}H_{41}$, | *artaxeuchal.* |
| Ceryl, | $C_{27}H_{55} = C_{27}H_{54}H$, | *weechal.* | Cerotyl, | $COC_{26}H_{53}$, | *artexeachal.* |
| Melissyl, | $C_{30}H_{61} = C_{30}H_{60}H$, | *weuchal.* | Melissilyl, | $COC_{29}H_{59}$, | *artexeachal.* |

In the acid-forming series, the presence of *art''* makes the sum of the increments of *ach''* one less than in the corresponding alcohol-forming radical.

An alcohol formed on the dyad type, like water, contains one monad radical, and the corresponding ether two. Two examples of each will suffice to show the manner of illustrating by the new characters their typical form : —

## ALCOHOLS.

| | | |
|---|---|---|
| Hydrate of methyl<br>or Wood spirit, | *Achal*<br>*al* | *at* = *Achelat.* |
| Hydrate of ethyl<br>or Common alcohol, | *Echal*<br>*al* | *at* = *Echelat.* |

## ETHERS.

| | | |
|---|---|---|
| Methylic oxide or<br>Methylic ether, | *Achal.*<br>*Achal* | *at* = *Achalemat.* |
| Ethylic oxide or<br>Ethylic ether, | *Echal*<br>*Echal* | *at* = *Echalemat.* |

The sulphydrates and sulphides of such radicals have structures similar to these alcohols and ethers. The following table of names shows the compound containing oxygen, and the corresponding compound containing sulphur: —

| | ALCOHOLS. | MERCAPTANS. | ETHERS. | SULPHIDES. |
|---|---|---|---|---|
| 1. Methylic | *Achelat.* | *Achelas.* | *Achalemat.* | *Achalemas.* |
| 2. Ethylic | *Echelat.* | *Echelas.* | *Echalemat.* | *Echalemas.* |
| 3. Propylic | *Ichelat.* | *Ichelas.* | *Ichalemat.* | *Ichalemas.* |
| 4. Butylic | *Ochelat.* | *Ochelas.* | *Ochalemat.* | *Ochalemas.* |
| 5. Amylic | *Uchelat.* | *Uchelas.* | *Uchalemat.* | *Uchalemas.* |
| 6. Caproylic | *Eachelat.* | *Eachelas.* | *Eachalemat.* | *Eachalemas.* |
| 7. Œnanthylic | *Eechelat.* | *Eechelas.* | *Eechalemat.* | *Eechalemas.* |
| 8. Caprylic | *Eichelat.* | *Eichelas.* | *Eichalemat.* | *Eichalemas.* |

As a specimen of the new names of more than 500 compounds containing an alcohol-forming radical, a few combinations with the most important, Ethyl (*echal*), are presented: —

| | | | |
|---|---|---|---|
| Fluoride of ethyl, | *echalf.* | Chloride of ethyl, | *echald.* |
| Bromide of ethyl, | *echalb.* | Iodide of ethyl, | *echalv.* |
| Cyanide of ethyl, | *echalarn.* | Hydride of ethyl, | *echel.* |

| | | |
|---|---|---|
| Acetate of ethyl, | $C_2H_5$-$COCH_3$-$O_2$, | *echal-artachalt.* |
| Monethylic oxalate, | $C_2H_5$-H-$C_2O_2O_2$, | *echelerot.* |
| Diethylic oxalate, | $(C_2H_5)_2$-$C_2O_2O_2$, | *echalemerot.* |
| Methyl-ethylic ether, | $CH_3 + C_2H_5$-$O$, | *achal-echalt.* |
| Methyl-amylic ether, | $CH_3 + C_5H_{11}O$, | *achal-uchalt.* |
| Ethyl-butylic ether, | $C_2H_5 + C_4H_9O$, | *echal-ochalt.* |
| Ethyl-amylic ether, | $C_2H_5 + C_5H_{11}O$, | *echal-uchalt.* |

Acid-forming radicals form anhybrides, corresponding in structure with simple ethers; and hydrates (acids) corresponding with alcohols. Examples of the names of acids of this class are here given: for the first term *al*, *l* is used to shorten the word.

| | | |
|---|---|---|
| Formic acid, | $H\text{-}COH\text{-}O$, | *Lartalt* = *achet.* |
| Acetic acid, | $H\text{-}COCH_3\text{-}O$, | *Lartachalt* = *echet.* |
| Propionic acid, | $H\text{-}COC_2H_5\text{-}O$, | *Lartechalt* = *ichet.* |
| Butyric acid, | $H\text{-}COC_3H_7\text{-}O$, | *Lartichalt* = *ochet.* |
| Valeric acid, | $H\text{-}COC_4H_9\text{-}O$, | *Lartochalt* = *uchet.* |
| Caproic acid, | $H\text{-}COC_5H_{11}\text{-}O$, | *Lartuchalt* = *eachet.* |
| Œnanthylic acid, | $H\text{-}COC_6H_{13}\text{-}O$, | *Larteachalt* = *eechet.* |
| Caprylic acid, | $H\text{-}COC_7H_{15}\text{-}O$, | *Larteechalt* = *eichet.* |
| Pelargonic acid, | $H\text{-}COC_8H_{17}\text{-}O$, | *Larteichalt* = *eochet.* |
| Rutilic acid, | $H\text{-}COC_9H_{19}\text{-}O$, | *Larteochalt* = *euchet.* |

Other combinations containing an acid-forming radical, which have been or may yet be formed, are illustrated by the names of compounds containing *artachal* (acetyl).

| | | | |
|---|---|---|---|
| Chloride of acetyl, | *artachald.* | Bromide of acetyl, | *artachalb.* |
| Aldehyde, | *artachel.* | Acetic anhydride, | *artachalemat.* |
| Sulphydrate of acetyl, | *lartachals.* | Sulphide of acetyl, | *artachalemas.* |
| Hydrate of chloracetyl, | *lartachadat.* | Hydrate of bromacetyl, | *lartachabat.* |
| Hydride of tribromacetyl, | *artacibel.* | Chloride of trichloracetyl, | *artacod.* |

Twenty-two other radicals, similar to *artachal*, may form hundreds of compounds by uniting with electro-negative elements.

ACETONES or KETONES, composed of an acid-forming radical and an alcohol-forming radical, have the constitution of the monad type. Of the fifteen bodies now known, seven are here cited: —

| | | |
|---|---|---|
| Methyl-acetyl (Acetone), | $CH_3,C_2H_3O$, | *achal-artachal.* |
| Methyl-butyryl, | $CH_3,C_4H_7O$, | *achal-artichal.* |
| Methyl-valyl, | $CH_3C_5H_9O$, | *achal-artochal.* |
| Ethyl-propionyl (Propione), | $C_2H_5,C_8H_5O$, | *echal-artechal.* |
| Ethyl-butyryl, | $C_2H_5,C_4H_7O$, | *echal-artichal.* |
| Propyl-butyryl (Butyrone), | $C_3H_7,C_4H_7O$, | *ichal-artichal.* |
| Butyl-valyl (Valerone), | $C_4H_9,C_5H_9O$, | *ochal-artochal.* |

In the following hydrocarbon homologous series, formed by multiples of *ach* and known as the olefiant-gas series, one atom of carbon saturates but two atoms of hydrogen, the equivalence being thus expressed: *or* ⇔ *el.* These bodies are dyads, each taking the place of two atoms of hydrogen in the water type.

| | | | | | |
|---|---|---|---|---|---|
| Methylene (not yet isolated), | $CH_2$, | *arlal.* | Ethylene or Olefiant gas, | $C_2H_4$, | *erlel.* |
| Propylene, | $C_3H_6$, | *irlil.* | Butylene (Oil gas), | $C_4H_8$, | *orlol.* |
| Amylene, | $C_5H_{10}$, | *urlul.* | Caproylene, | $C_6H_{12}$, | *earleal.* |
| Œnanthylene, | $C_7H_{14}$, | *eerleel.* | Caprylene, | $C_8H_{16}$, | *eirliel.* |
| Elaene, | $C_9H_{18}$, | *eorleol.* | Paramylene, | $C_{10}H_{20}$, | *eurleul.* |

This series unite with dyads, and also with two atoms of a monad, of which the annexed are specimens: —

| | | |
|---|---|---|
| Oxide of ethylene | or Glycolic ether, | *erlelat* or *echat.* |
| Oxide of propylene | or Propyl-glycolic ether, | *irlilat* or *ichat.* |
| Oxide of butylene | or Butyl-glycolic ether, | *orlolat* or *ochat.* |
| Oxide of amylene | or Amyl-glycolic ether, | *urlulat* or *uchat.* |
| Hydrate of ethylene | or Ethylic-glycol, | *erlelelt* or *echelt.* |
| Hydrate of propylene | or Propylic glycol, | *irlilelt* or *ichelt.* |
| Hydrate of butylene | or Butylic glycol, | *orlolelt* or *ochelt.* |
| Hydrate of amylene | or Amylic glycol, | *urlulelt* or *uchelt.* |

The hydrate of glyceryl, $[C_3H_5\text{-}H_3]O_3$ = *echarlilt,* is a triad alcohol. If *il,* the second term, is replaced by three atoms of the monad *anet* = *ineal,* the interesting explosive compound Nitroglycerine is formed, the three terms of the type being [*echarl-ineat*] *it* = *echarlineot.* On the other hand, if *il* in *echarlilt* be replaced by three atoms of the monad-acid radical $COC_{17}H_{35}$, *artaxeechal,* the compound known as Tristearin is formed, containing . . . . . . $C_{57}H_{110}O_6$ = *uxuchereat.* In like manner, only two or one atom of hydrogen may be replaced by two or one atom of the acid-radical.

Artificial fats may have been formed by the action of acids on glycerin, *echarlilt*; and the following from among the glycerides are presented, with their new empirical names: —

| | | | | | |
|---|---|---|---|---|---|
| Monacetin, | $C_5H_{10}O_4$, | *uchot.* | Monolein, | $C_{21}H_{40}O_4$, | *axeucharot.* |
| Monobutyrin, | $C_7H_{14}O_4$, | *eechot.* | Monopalmitin, | $C_{19}H_{38}O_4$, | *axeechot.* |
| Monovalerin, | $C_8H_{16}O_2$, | *eichot.* | Monostearin, | $C_{21}H_{42}O_2$, | *exachot.* |

That modification of sugar known as glucose or starch sugar, $C_6H_{12}O_6$, has lately been regarded by some chemists as a hexatomic or hexad alcohol. According to this view, its new name is *earlealt.* There are about thirty varieties of sugars and gums of nearly the same composition, to which new names should not be given until there is a general agreement among chemists as to their composition and constitution.

Artificial alkaloids, or compound ammonias of Wurtz and Hoffman, formed on the triad or ammonia type [*al-al-al*]*an,* in which an atom of hydrogen is replaced by a radical, are thus illustrated: —

| METHYLAMINE. | ETHYLAMINE. | AMYLAMINE. | PHENYLAMINE.<br>(Aniline.) |
|---|---|---|---|
| $\left.\begin{matrix}\textit{achal}\\ \textit{al}\\ \textit{al}\end{matrix}\right\}\textit{an},$ | $\left.\begin{matrix}\textit{echal}\\ \textit{al}\\ \textit{al}\end{matrix}\right\}\textit{an},$ | $\left.\begin{matrix}\textit{uchal}\\ \textit{al}\\ \textit{al}\end{matrix}\right\}$ | $\left.\begin{matrix}\textit{earolal}\\ \textit{al}\\ \textit{al}\end{matrix}\right\}$ |
| *achilan.* | *echilan.* | *uchilan.* | *earolilan* or *eareelan.* |

| DIMETHYLAMINE. | DIETHYLAMINE. | DIAMYLAMINE. | DIPHENYLAMINE. |
|---|---|---|---|
| $\left.\begin{array}{r}\textit{achal}\\ \textit{achal}\\ \textit{al}\end{array}\right\}\textit{an},$ | $\left.\begin{array}{r}\textit{echal}\\ \textit{echal}\\ \textit{al}\end{array}\right\}\textit{an},$ | $\left.\begin{array}{r}\textit{uchal}\\ \textit{al}\\ \textit{al}\end{array}\right\}\textit{an},$ | $\left.\begin{array}{r}\textit{earolal}\\ \textit{earolal}\\ \textit{al}\end{array}\right\}\textit{an},$ |
| *achalemalan.* | *echlemalan.* | *uchalemalan.* | *earulemalan.* |

| TRIMETHYLAMINE. | TRIETHYLAMINE. | TRYAMYLAMINE. | TRIPHENYLAMINE. |
|---|---|---|---|
| $\left.\begin{array}{r}\textit{achal}\\ \textit{achal}\\ \textit{achal}\end{array}\right\}\textit{an},$ | $\left.\begin{array}{r}\textit{echal}\\ \textit{echal}\\ \textit{echal}\end{array}\right\}\textit{an},$ | $\left.\begin{array}{r}\textit{uchal}\\ \textit{uchal}\\ \textit{uchal}\end{array}\right\}\textit{an},$ | $\left.\begin{array}{r}\textit{earolal}\\ \textit{earolal}\\ \textit{earolal}\end{array}\right\}\textit{an},$ |
| *achaliman.* | *echaliman.* | *uchaliman.* | *earuliman.* |

Three different radicals may be found in the same compound. To denote this, requires names somewhat longer than the preceding: thus, —

| | | |
|---|---|---|
| Methyl-ethyl-phenylamine, | $[CH_3\text{-}C_2H_5\text{-}C_6H_5]N$, | is *achal-echal-earulan.* |
| Diethyl-chloro-phenylamine, | $[(C_2H_5)_2C_6H_4Cl]N$, | is *echalem-earoladan.* |

Other triad elements form similar compounds. From the tertiary derivations are selected the following two: —

Bromide of bromethyl-triethyl-phosphonium = *echeb-echalimap.*
Bromide of ethylene-hexethyl-diphosphonium = *echeb-echaleamep.*

Some of the denser molecules of hydrocarbons are here presented: —

| | | |
|---|---|---|
| Cetylene | $= C_{16}H_{32}$, | *yeach.* |
| Cetylic alcohol | $= C_{16}H_{34}O$, | *yeachelat.* |
| Cerene (paraffin) | $= C_{27}H_{56}$, | *weech.* |
| Cerylic alcohol | $= C_{27}H_{26}O$, | *iweechelat.* |
| Melene (paraffin) | $= C_{30}H_{60}$, | *weuch.* |
| Melissylic alcohol | $= C_{30}H_{62}O$, | *weuchelat.* |
| Spermaceti (pure) | $= C_{32}H_{64}O_2$ | *ixechet.* |
| Myricin | $= C_{46}H_{92}O_2$, | *oxeachet.* |
| Chinese wax | $= C_{54}H_{108}O_2$, | *uxochet.* |

Combinations of metals with alcohol-forming radicals, or metallic derivatives of alcohols: —

| | | |
|---|---|---|
| Kakodyl (auct. BUNSEN), | $As(CH_3)_2$, | *Arsmereal* or *achalem-arsam.* |
| Arsenio-monomethyl (auct. BAEYER), | $AsCH_3$, | *Arsmaril* or *achal-arsam.* |
| Arsenio-trimethyl, | $As(CH_3)_3$, | *Arsmirœl* or *achalalim-arsam.* |
| Arsenio-tetramethyl, | $As(CH_3)_4$, | *Arsmoroil* or *achalom-arsam.* |
| Quadrichloride of arsenio-monomethyl, | $AsCH_3Cl_5$, | *Arsmarilod* or *achal-arsamod.* |
| Triethyl-bismuthene, | $(C_2H_5)$ Bi, | *echalim-bisam.* |
| Trimethyl-stibio, | $(CH_3)_3$ Sb, | *Stibmcheol* or *achalim-stibam.* |
| Stibio-tetramethylium, | $(CH_3)_4$ Sb, | *achalom-stibam.* |
| Chloride of stibio-tetramethylium, | $(CH_3)_4$ SbCl, | *achalom-stibmad.* |
| Oxide of stibio-tetramethylium, | $(CH_3)_6$ SbO, | *achaleim-stibamet.* |
| Nitrate of stibio-tetramethylium, | $(CH_3)_4$ $SbNO_3$, | *achalom-stibmanit.* |
| Neutral Sulphate of stibio-tetramethylium, | | *achaleim-stibemasot.* |

| | | |
|---|---|---|
| Zinc-dimethyl, | $(CH_3)^2Zn$, | *Zinmereal* or *achalem-zinam*. |
| Zinc-diethyl, | $(C_2H_5)^2Zn$, | *echalem-zinam*. |
| Zinc-diamyl, | $(C_5H_{11})^2Zn$, | *uchalem-zinam*. |
| Cadmium-diethyl, | $(C_2H_5)^2Cd$, | *echalem-cadam*. |
| Magnesium-diethyl, | $(C_2H_5)^2Mg$, | *echalem-magam*. |
| Stannic ethide, | $(C_2H_5)^4Sn$, | *echalom-stannam*. |
| Plumbo-tetrethyl, | $(C_2H_5)^4Pb$, | *echalom-plubam*. |
| Hydrargo-dimethyl, | $(CH_3)^2Hg$, | *achalem-hygam*. |

From the products of destructive distillation, the following homologous series is selected, which must be recognized principally by the first syllable denoting the amount of carbon; for by substitutions and combinations, the hydrogen of these bodies may all be displaced, and numerous compounds formed which are indicated by terms having no part of the original name except that defining the carbon.

| | | | | | |
|---|---|---|---|---|---|
| Benzol or Benzene, or Hydride of phenyl, $C_6H_4H_2$ | | | | | *earl* or *earolel*. |
| Toluol, | $C_7H_6H_2$, | *eerealel*. | Xylol, | $C_8H_8H_2$, | *eirlel*. |
| Cumol, | $C_9H_{10}H_2$, | *eoreulel*. | Cymol, | $C_{10}H_{12}H_2$, | *euroilel*. |

Compounds related to the first body only of this series will be noted:—

The Hydride of phenyl, $C_6H_6$, *earolel*, is formed on the monad type.

Chloride of phenyl or Monochloride of benzene, is *earolald;* and

Bromide of phenyl or Monobromide of benzene, is *earolalb*.

The Hydrate of phenyl, better known as Carbolic or Phenic acid, sometimes called Phenic alcohol and Phenol, has the empirical name of *earlat*. As an alcohol, its new name would be *earolelat;* as an acid, *learolalt*. Its relation with aniline will be recognized by the empirical name of aniline (as well as of picodine), *eareelan*, the typical name being *earolilan;* or if the radical is expressed in two syllables, *earulelan*, i.e. Monophylamine; thus Triphenylamine is expressed by *earuliman*.

In the following table are embraced the known dyad homologues of the carbonic-acid and oxalic-acid series, formed by the increment *ach:*—

| | | |
|---|---|---|
| Carbonic acid (hypothetical hydrate), | $H_2\ CO_3$, | *el-arit*. |
| Glycolic acid, | $C_2H_4O_3 = H_2\ CH_2\ CO_3$, | *el-acharit*. |
| Lactic acid, | $C_3H_6O_3 = H_2\ C_2H_4\ CO_3$, | *el-echarit*. |
| Butilactic acid, | $C_4H_8O_3 = H_2\ C_3H_6\ CO_3$, | *el-icharit*. |
| Phocic acid, | $C_5H_{10}O_3 = H_2\ C_4H_8\ CO_3$, | *el-ocharit*. |
| Leucic acid, | $C_6H_{12}O_3 = H_2\ C_5H_{10}\ CO_3$, | *el-ucharit*. |

| | | | |
|---|---|---|---|
| Oxalic acid, | $H_2C_2O_4$, | | *el-erot.* |
| Malonic acid, | $C_3H_4C_4$ | $= H_2\,CH_2\,C_2O_4$, | *el-acherot.* |
| Succinic acid, | $C_4H_6O_4$ | $= H_2\,C_2H_4\,C_2O_4$, | *el-echerot.* |
| Pyrotartaric acid, | $C_5H_8O_4$ | $= H_2\,C_3H_6\,C_2O_4$, | *el-icherot.* |
| Adiptic acid, | $C_6H_{10}O_4$ | $= H_2\,C_4H_8\,C_2O_4$, | *el-ocherot.* |
| Pimelic acid, | $C_7H_{12}O_4$ | $= H_2\,C_5H_{10}\,C_2O_4$, | *el-ucherot.* |
| Suberic acid, | $C_8H_{14}O_4$ | $= H_2\,C_6H_{12}\,C_2O_4$, | *el-eacherot.* |
| Anchoic acid, | $C_9H_{16}O_4$ | $= H_2\,C_7H_{14}\,C_2O_4$, | *el-eecherot.* |
| Sebacic acid, | $C_{10}H_{18}O_4$ | $= H_2\,C_8H_{16}\,C_2O_4$, | *el-eicherot.* |

The substitution of a dyad metal, or two atoms of a monad metal, for *el* in this series, will form the corresponding metallic salts.

In a similar manner may be classified alkaloids; for instance, those obtained by dry distillation of animal matter: —

| | | | |
|---|---|---|---|
| Pyridine, | $C_5H_5N$, | | *urlan.* |
| Picoline, | $C_6H_7N$ | $= CH_2C_5\,H_5N$, | *achurlan.* |
| Lutidine, | $C_7H_9N$ | $= (CH_2)^2\,C_5H_5N$, | *echurlan.* |
| Collidine, | $C_8H_{11}N$ | $= (CH_2)^3\,C_5H_5N$, | *ichurlan.* |
| Pavoline, | $C_9H_{13}N$ | $= (CH_2)^4\,C_5H_5N$, | *ochurlan.* |

**Substitutions.** Dumas' doctrine of substitutions is very clearly set forth in the following examples: —

1. Marsh gas = *arol.* Chloride of methyl (*achald*) = *arilad.*
Monochlorinated chloride of methyl, *areled.*
Dichlorinated chloride of methyl (chloroform), *arlid.*
Perchlorinated chloride of methyl, *arod.*

2. Ethylene, *erlel.* Chlorinated ethylene, *erlald.*
Dichlorinated ethylene, $C_2H_2Cl_2$, *erled.*
Trichlorinated ethylene, $C_2HCl_3$, *erulid.*
Perchlorinated ethylene, $C_2Cl_4$, *erod.*

3. The action of chlorine on ethylene and chloride of ethyl produces metameric compounds having widely different boiling points, thus distinguished: —

| | | |
|---|---|---|
| Dichloride of ethylene (Dutch liquid), | $C_2H_3\,HCl_2$, | = *erleld.* |
| Monochlorinated chloride of ethyl, | $C_2H_4\,ClCl$, | = *eched.* |
| Monochlorinated dichloride of ethylene, | $C_2H_3\,ClCl_2$, | = *erlalid.* |
| Dichlorinated chloride of ethyl, | $C_2H_3\,Cl_3$, | = *ecilid.* |
| Dichlorinated dichloride of ethylene, | $C_2H_2\,Cl_2Cl_2$ | = *erlod.* |
| Trichlorinated chloride of ethyl, | $C_2H_2\,Cl_4$, | = *eclod.* |
| Trichlorinated dichloride of ethylene, | $C_2H\,\,Cl_2Cl_3$ | = *eralud.* |
| Tetrachlorinated chloride of ethyl, | $C_2\,H\,Cl_5$, | = *ecalud.* |
| Perchlorinated dichloride of ethylene | $C\,\,Cl_4Cl_2$, | = *eread.* |
| Perchlorinated chloride of ethyl, | $C_2\,Cl_6$, (identical) | *eread.* |

4. Naphthalene, $C_{10}H_8$, *eureil.* (Paranaphthaline, $C_{14}H_{10}$, *yoreul.*)

| | | | |
|---|---|---|---|
| Chloronaphthaline, | *eureelad.* | Bromonaphthaline, | *eureelab.* |
| Dichloronaphthaline, | *eurealed.* | Dibromonaphthaline, | *curealeb.* |
| Trichloronaphthaline, | *eurulid.* | Tribromonaphthaline, | *eurulib.* |
| Tetrachloronaphthaline, | *eurold.* | Tetrabromonaphthaline, | *eurolb.* |
| Hexachloronaphthalene, | *eurelead.* | Perchloronaphthaline, | *eureid.* |

5. CHLORIDES and BROMIDES of NAPHTHALINE, with GMELIN'S names aud formulæ: —

| | | |
|---|---|---|
| Hydrochlorate of chloronaphthaline, | $C_{10}H_7Cl\ HCl$ | = *eureiled.* |
| Hydrochlorate of chlorobromonaphthaline, | $C_{10}H_6BrCl\ HCl$ | = *eureelabed.* |
| Hydrobromate of quadribromonaphthaline, | $C_{10}H_4Br_4\ HBr$ | = *eurulb.* |
| Bihydrochlorate of bichloronaphthaline, | $C_{10}H_6Cl_2\ 2\ HCl$ | = *eureilod.* |
| Bihydrochlorate of bromochloronaphthaline, | $C_{10}H_6BrCl\ 2\ HCl$ | = *eureilabid.* |
| Bihydrochlorate of terchloronaphthaline, | $C_{10}H_5Cl_3\ 2\ HCl$ | = *eureelud.* |
| Bihydrochlorate of quadrichloronaphthaline, | $C_{10}H_4Cl_4\ 2\ HCl$ | = *eureald.* |
| Bihydrochlorate of bibromobichloronaphthaline, | $C_{10}H_4Br_2Cl_2\ 2\ HCl$ | = *eurealebod.* |
| Bihydrobromate of bibromobichloronaphthaline, | $C_{10}H_4Br_2Cl_2\ 2\ HBr$ | = *eurealedob.* |
| Bihydrobromate of terbromochloronaphthaline, | $C_{10}H_4Br_3Cl\ 2\ HBr$ | = *eurealadub.* |
| Bihydrobromate of quadribromonaphthaline, | $C_{10}H_4Br_4\ 2\ HBr$ | = *eurealb.* |
| Bihydrochlorate of bibromoterchloronaphthaline, | $C_{10}H_3Br_2Cl_3\ 2\ HCl$ | = *eurulebod.* |
| Bihydrobromate of pentabromonaphthaline, | $C_{10}H_3Br_5\ 2\ HBr$ | = *euruleeb.* |

**Isomerism.** By applying the principle of permutation in the arrangement of letters, the same name is never given to metameric bodies having the same ultimate composition. A few examples will sufficiently prove the adaptation of the new system to cases of isomerism. Each of the following ten bodies has the empirical formula $C_{10}H_{20}O_2$: —

| | | |
|---|---|---|
| Rutic or Capric acid, | $H\ CO\ C_9H_{18}O$, | *Larteochalt.* |
| Formiate of elayl, | $C_9H_{19}\ CO\ HO$, | *eochal-artalt.* |
| Acetate of capryl, | $C_8H_{17}\ CO\ CH_3O$, | *eichal-artachalt.* |
| Propionate of œnanthyl, | $C_7H_{15}\ CO\ C_2H_5O$, | *eechal-artechalt.* |
| Butyrate of caproyl, | $C_6H_{13}\ CO\ C_3H_7O$, | *eachal-artichalt.* |
| Valerate of amyl, | $C_5H_{11}\ CO\ C_4H_9O$, | *uchal-artochalt.* |
| Caproate of butyl, | $C_4H_9\ CO\ C_5H_{11}O$, | *ochal-artuchalt.* |
| Œnanthate of propyl, | $C_3H_4\ CO\ C_6H_{13}O$, | *ichal-arteachalt.* |
| Caprylate of ethyl, | $C_2H_5\ CO\ C_7H_{15}O$, | *echal-arteechalt.* |
| Pelargonate of methyl, | $CH_3\ CO\ C_8H_{17}O$, | *achal-arteichalt.* |

Each of the seven following compound ammonias has the same ultimate composition, $C_6H_{15}N$: —

| | | |
|---|---|---|
| Triethylamine, | $(C_2H_5)^3$ N, | *echaliman.* |
| Dipropylamine, | $(C_3H_7)^2$ H N, | *ichalemalan.* |
| Caproylamine, | $C_6H_{13}$ $H_2N$, | *eachilan.* |
| Amyl-methylamine, | $C_5H_{11}$ $CH_3HN$, | *uchal-achelan.* |
| Butyl-dimethylamine, | $C_4H_9$ $(CH_3)^2$ N, | *ochal-achaleman.* |
| Butyl-ethylamine, | $C_4H_9$ $C_2H_5$ HN, | *ochal-echelan.* |
| Propl-ethyl-methylamine, | $C_3H_7$ $C_2H_5$ $CH_3N$, | *ichal-echal-achalan.* |

TWO AMMONIA-COBALT METAMERS, empirical formula $(H_3N)$ $CCl_3$, are here cited: —

| | |
|---|---|
| Roseo-pentammonia-cobaltic chloride, | *ilanum-cobamid.* |
| Purpureo-pentammonia-cobaltic chloride, | *yulun cobamid.* |

It has already been admitted that the improved names, as found in Watts' New Dictionary, have the merit of more precision than the old nomenclature in designating the proportions of non-metallic elements; but this precision is not always observed in that portion of the name defining the metal. For the purpose of comparison, a few of the names given as examples under the article on Nomenclature, page 125, are here inserted, with the symbols. and the proposed new names: —

| | | |
|---|---|---|
| Platinic dichloride | = $PbCl_2$, | *Platamed.* |
| Diplumbic trioxide | = $Pb_2O_3$, | *Plubemit.* |
| Triplumbic tetroxide | = $Pb_3O_4$, | *Plubimot.* |
| Diplumbo-dihydric trioxide | = $[Pb_2H_2]O_3$, | *Plubemelit.* |
| Triplumbo-dihydric tetroxide | = $[Pb_3H_2]O_4$, | *Plubimelot.* |
| Bismuthic oxichloride | = $BiClO$, | *Bisamadat.* |
| Diplumbic oxidichloride | = $Pb_2Cl_2O$, | *Plubemedat.* |
| Triplumbic dioxidichloride | = $Pb_3Cl_2O_2$, | *Plubimedet.* |
| Trimercurio-dioxidichloride | = $Hg_3Cl_2O_2$, | *hygimedet.* |
| Hydrargyro-dihydric-chloronitride | = HgCl $H_2N$, | *hygmadelan.* |
| Tetramercurio-tetrahydric-trioxidinitride | = $H_4N_2$ $Hg_4O_3$, | *olen-hygomit.* |
| Tetramercurio-tetrahydric-dioxidichlorodinitride | = $Hg_4H_4Cl_2N_2O$ , | *hygom-oledent.* |

WATER has three distinct functions recognized in the notation, but not in the common nomenclature, which are clearly defined in the new system.

1. Water as a true chemical component: it is thus designated by *elat*, *alalt* or *lalt*. The first of these names, when forming a part of another name, may denote the typical structure and the rational formula of the compound: it may indicate, likewise, that precisely the same number and kind of atoms, by another arrangement, would form two independent and stable bodies; for instance, *echelat* denotes that

alcohol is formed by the combination of the radical *echal* with the water torso *alat* or *alt*, and is modelled after the dyad type; it also indicates the fact proved by the synthetic process of Berthelot, that alcohol contains all and precisely the components forming olefiant gas and water. The other name of water, *alalt* or *lalt*, shows more clearly how the torso *alt*, torn from *al*, will unite with a monad radical or metal and form a perfect body, like, for example, hydrate of potash, *potamalt;* hydrate of lime, *calcamelt.*

2. Water as a mechanical component of certain crystals. Under the plastic trowel of symmetry, it fills the interstices, so to speak, builds up and completes the structure. During this mysterious process of construction, the pair of hydrogen atoms are supposed to still cling to oxygen; and the molecule having such close atomic ties is distinguished by the term *allt.* This is the only case where the same consonants are found side by side: the relation in which the word is used will prevent its being confounded with the torso *alt.* By changing the vowel prefix, any number of molecules, either of water of crystallization, or of constitutional water, as Graham styles it, may be denoted. As a general rule, this name precedes the essential name of the compound; for example: —

| | |
|---|---|
| Crystallized periodic acid, with 4 atoms of water, | *ollt-alavot.* |
| Crystallized oxalic acid with 2 aqua, | *ellt-elerot.* |
| Prismatic nitrate of copper with 3 aqua, | *illt-cupmeneat.* |
| Rhomboidal nitrate of copper with 6 aqua, | *eallt-cupmeneat.* |
| Nitrate of lime with 4 aqua, | *ollt-calcmeneat.* |
| Nitrate of strontia with 5 aqua, | *ullt-stronmeneat.* |
| Nitrate of lithia with 5 aqua, | *ullt-lithmanit.* |
| Protonitrate of iron with 6 aqua, | *eallt-fermeneat.* |
| Hyposulphite of soda with 5 aqua, | *ullt-sodemasit.* |
| Sulphate of soda with 10 aqua, | *eullt-sodemasot.* |
| Carbonate of soda with 10 aqua, | *eullt-sodemarit.* |
| Sulphate of alumina and potash with 24 aqua, | *wolltalem-potemosoit.* |
| Sulphate of alumina and thallium with 24 aqua, | *wolltalem-thallemosoit.* |

3. Water as a solvent or menstruum, modifying, in proportion to its quantity, the chemical power and functions of the compound held in solution. The complete and equable diffusion of a soluble body, by which its characteristics are manifested through the medium of this fluid, may be regarded as the effect of a contiguity resulting from molecular rather than atomic attraction. In this case, the pair of hydrogen atoms are designated by the letter *h*, and the oxygen atom by

*t;* and *th*, as a prefix to the name of a compound, denotes that such compound is held in solution by an indefinite quantity of water. Any amount corresponding to a definite number of molecules of water may be represented by the usual vowels placed before *th*. The following brief exhibit of names will show the economy and precision of expression applicable to substances now commonly called and recognized only by misnomers.

| | |
|---|---|
| A solution of hydrochloric acid and water, | *thalad.* |
| Fuming solution containing 48 per cent. of HCl or 6 aqua, | *eathalad.* |
| Solution of HCl which distils unchanged (20 per cent. acid, or 16 aqua), | *authalad.* |
| Hydrate of chlorine $(H_2O)^5$ Cl, | *uthad.* |
| Sulphuric acid, distinguished as oil of vitriol, | *elasot.* |
| Sulphuric acid with indefinite quantity of water, | *thelasot.* |
| Glacial sulphuric acid, | *athelasot.* |
| Nitric acid, indefinite solution by water, | *thalanit.* |
| Nitric acid, solution containing 60 per cent $NO_3$ or 3 aqua, | *ithalanit.* |
| Solution of ammonia and water, | *thilan.* |
| Solution of alcohol and water, | *thechelat.* |
| Solution of carbonic anhydride (soda water), | *tharet.* |

In the further progress of chemical investigations, increasing significance must be given to the state of dilatation of the body under examination. On passing from the solid to the liquid state, its bulk will undergo but comparatively little change. In either state, the restless particles which make up the apparently unmoved mass are still obedient to the law of cohesion, although in the liquid the league of homogeneity is not so binding as to prevent the admission of foreign matter; but when, by the irresistible power of the almost infinitesimal motions of a subtle medium, heat accelerates and amplifies the excursions of particles until they fly simultaneously beyond the dominion of a common attraction, it must be admitted that the mass thus expanded to the gaseous state — in reality a vast reservoir of molecular momentum — requires some distinctive appellation. It is therefore proposed to denote every gaseous compound, and every volatile body after it has fumed into vapor, by simply prefixing to its new name the letter *g*.

Were it desirable to show the degree of condensation of gases produced by their combination, the number of volumes included in one molecule could be indicated by the usual vowels before *g;* but as the number of atoms now conforms to the number of volumes of gaseous elements, in most cases, the amount of condensation can be easily estimated. At present it seems essential only to indicate that the molecule has assumed a state of gas or vapor.

The succeeding names are illustrations: —

| **GASES** at ordinary temperatures. | |
|---|---|
| Carbonic oxide, | *gart.* |
| Carbonic anhydride, | *garet.* |
| Oleflant gas, | *gerlel.* |
| Oil gas, | *gorlol.* |
| Nitrous oxide, | *genat.* |
| Binoxide of nitrogen, | *gant.* |
| Nitrous anhydride, | *ganit.* |
| Sulphuretted hydrogen, | *gelas.* |
| Ammonia, | *gilan.* |
| Phosphuretted hydrogen, | *gilap.* |
| Arseniuretted hydrogen, | *gil-arsam.* |
| Antimoniuretted hydrogen, | *gil-stibam.* |
| Cyanogen (molecule), | *gern.* |
| Sulphurous anhydride, | *gaset.* |
| Hypochlorous anhydride, | *gedat.* |
| Euchlorine, | *gadadat.* |
| Chlorous anhydride, | *gedit.* |
| Hydrochloric acid gas, | *galad.* |
| Hydrobromic acid, | *galab.* |
| Hydriodic acid, | *galav.* |
| Oxychloride of carbon, | *garted.* |
| Carburetted hydrogen, | *garol.* |
| Hydride of ethyl, | *gechel.* |
| Ethylide of ethyl, | *gechalem.* |
| Chloride of methyl, | *gachald.* |
| Methylic ether, | *gachalemat.* |

| **VAPORS** at heat stated on centigrade scale. | | |
|---|---|---|
| Chloride of ethyl | 11°, | *gechald.* |
| Bromide of methyl | 18°, | *gachalb.* |
| Oxide of ethylene | 13°.5, | *gechat.* |
| Hydrofluoric acid | 16°, | *galaf.* |
| Peroxide of nitrogen | 27°, | *ganet.* |
| Sulphuric anhydride | 27°, | *gasit.* |
| Prussic acid | 88°, | *galarn.* |
| Ethylic ether | 34°, | *gachalemat.* |
| Amylene | 39°, | *gurlul.* |
| Chloride of methylene | 40°, | *gached.* |
| Protosulphide of methyl | 41°, | *gachelemas.* |
| Iodide of methyl | 42°, | *gachalv.* |
| Nitric anhydride | 45°, | *ganut.* |
| Bisulphide of carbon | 47°, | *gares.* |
| Bromide of ethyl | 47°.7, | *gechalb.* |
| Hydrideof methyl | 60°, | *gachelat.* |
| Chloroform | 61°, | *garlid.* |
| Sulphochloride of carbon | 70°, | *garsed.* |
| Caproylene | 71°, | *gearleal.* |
| Iodide of ethyl | 72°, | *gechalv.* |
| Bichloride of carbon | 78°, | *garod.* |
| Perchloride of phosphorus | 78°, | *gapid.* |
| Absolute alcohol | 78°, | *gechelat.* |
| Dichloride of ethylene | 85°, | *gerleld.* |
| Œnanthylene | 99°, | *geerleel.* |
| Steam | 100°, | *gelat.* |

In anticipation of an inquiry as to the feasibility of applying the new nomenclature to all known chemical bodies, it may be here observed that new names have been framed for a large majority of the compounds enumerated in Storer's Dictionary of Solubilities, as well as for many modifications described in Dana's Mineralogy; yet as these names form a lexicon of chemical compounds, they cannot properly be applied to the large class about the composition of which there is still a wide diversity of opinion, particularly to those treated of in zoöchemistry, from whose percentage-analysis no satisfactory formulæ have thus far been deduced. No objection can be made, however, to the application of new terms to those compounds now designated only by symbols, or to new bodies not yet named; such, for example, as Loew's new combination of hydrogen with the sesquisulphide of carbon, *aleris*.

Should the proposed system be favorably received, the most effectual mode of bringing it into general use would be to add to the old name of a body the new name in italics, in lieu of the ordinary symbols which now involve the use of very small figures not always read with facility. These symbols have been aptly termed the *short-hand* of the chemist; yet in a large majority of instances, the corresponding new names contain a smaller number of syllables; for example, $CO_2$ is pronounced with three syllables, and *garet* with two; $H_2O$ with three syllables, *elat* with two; $HO$ with two, *alt* with one; $COCl_2$ with five, and *garted* with two.

Those objecting to the use of chemical equations, will observe how readily the new names may be substituted for such expressions by the following examples: —

$H_2Cl_2 + Na_2O = Na_2Cl_2 + H_2O$:
*eled* with *sodemat* yields *sodemed* and *elat*.

$H_2SO_4 + ZnSO = ZnSO_4 + H_2O$:
*elasot* with *zinamat* yields *zinmasot* and *elat*.

$H_2SO_4 + Zn = ZnSO_2 + H_2$:
*elasot* with *zinam* yields *zinmasot* and *hydrel*.

$CaN_2O_6 + Na_2SO_4 = Na_3 N_2O_6 + CaSO_4$:
*calcmeneat* and *sodemasot* yield *sodemeneat* and *calmasot*.

Williamson's original view of the constitution of ethers is illustrated by the following substitute for the equation explaining the reactions which produce the oxide of diethyl: —

*sodam-echalt* with *echalv*, yields *Sodamav* and *echalemat*.

The use of the new nomenclature in conversations on chemical subjects would correct very soon many vulgar errors, and inculcate, by mere imitation and habit, clearer views of combinations. He who knows why he calls chloroform *arlid*, knows on the instant, and knows for life, that it is composed of one of carbon, one of hydrogen and three atoms of chlorine; or when he designates laughing gas by *genat*, he announces at once several facts not indicated by the old names, nitrous oxide or protoxide of nitrogen.

Chemical writers, who are obliged to study brevity of expression, will fully appreciate the saving of pen and type-work resulting from the use of the new nomenclature, which may often be as marked as in the following announcement of a late scientific achievement in old and new phrase placed side by side: —

| | |
|---|---|
| **Lossen** has succeeded in replacing [an atom of hydrogen in ammonia by an atom of hydrogen and oxygen, or hydroxyl; thus forming hydroxalamine]. | **Lossen** has succeeded in replacing [*al* in *ilan* by *alt*; thus forming *altelan*]. |

TYPE. 𝔖:

$$\left.\begin{matrix} al \\ al \\ al \end{matrix}\right\} an \leftrightarrow \left.\begin{matrix} alt' \\ al \\ al \end{matrix}\right\} an.$$

Very few of the best practical chemists attempt to tax the memory with the exact symbolic formulæ of many compounds whose functions and general characteristics are well known to them; yet they are aware that the application of the theory of substitutions, in the higher branches of the science, depends on a correct conception of atomic proportions. They would therefore advise the young student, whom doubt hampers quite as effectually as downright ignorance, to avail himself of the best means to master what is known, and thus prepare himself to keep abreast the general progressive movement, and to meet the practical difficulties that constantly beset the way of the discoverer.

In conclusion, it is proper to say that only such examples have been cited as seemed essential to prove the copiousness and capacity of the proposed nomenclature. A more complete elucidation and application of it is reserved for succeeding papers.

## IV. PHYSICS OF THE GLOBE.

### 1. On the Periodicity of the Aurora Borealis. By Joseph Lovering, of Cambridge, Mass.

As this paper will appear in full in the Memoirs of the American Academy of Arts and Sciences, over two hundred pages of which were presented in sheets to the Association, only a brief abstract will be given in this place. I was incited to the study of the laws of periodicity of the aurora by the absence of any recorded appearances of this display, in this country, before the early part of the eighteenth century, a failure in the record which could not easily be explained except by a failure in the phenomenon itself, especially when it is considered that the early settlers of New England were not likely to have overlooked appearances which they could so readily associate with the religious or political events of their heaven-determined destiny. A preliminary discussion of the subject was first published in the American Almanac for 1860, and afterwards, with some modification, in the Memoirs of the American Academy, Vol. IX. p. 101. But I was soon satisfied that no satisfactory solution of a vast problem could be reached, which was built on anything less than the richest materials that could be gathered from the records of science. Much time has been expended, therefore, in preparing and printing a complete catalogue of all the auroras observed from the earliest times down to the present year, — a catalogue which comprises about ten thousand independent auroras and fifty thousand observations.

The discussion of these materials, so far as it has yet progressed, relates especially to the distribution of auroras between the different days and months of the year, and the accuracy with which this distribution may be expressed by a periodical function. The subject is considered, not only for the whole earth, but also separately for the two hemispheres, and for each place where a series of observations has continued long enough to justify a distinct discussion. The number of auroras occurring in different seasons of the year has been computed by the following formula:

$$N = A + C_1 \sin. 2\pi (t + c_1) + C_2 \sin. 4\pi (t + c_2) + C_3 \sin. 6\pi (t + c_3);$$

and the result compared with the observations. The mean probable error has been obtained by the usual rule applied to the differences between the number of observed and computed auroras. The formula just mentioned is the same as I employed in 1845 in discussing the daily changes of temperature and magnetic declination at Cambridge, Mass.[*] In 1843 Eklöf published[†] at Helsingfors, Russia, a mathematical investigation of the yearly march of auroral phenomena, in which he employed the same periodic function as I have adopted. Copies, however, of the Scientific Transactions, in which Eklöf published his labors are very rare in this country. I only know of the single one which I had recently an opportunity to examine, in the Astor Library, of New York. As Eklöf confined his inquiry to a few places, and to small and imperfect catalogues of auroras, what I have added to his work may not, perhaps, be superfluous.

I have taken notice in my memoir of the attempts made by Mairan, Ritter, Höslin, Quetelet, Wartmann, Boué, Baumhauer, Wolf, A. de la Rive, Fritz, and Littrow, to establish relations between the periods of auroral maxima and minima and those of shooting stars, meteors, earthquakes, disturbances in the earth's magnetism, or the sun's inflamed surface, and even the larger nutation-period of the earth's axis, to say nothing of hail-storms, snow-storms, lunar halos, winds, etc.

Since the first two hundred and forty pages of my Memoir on the Periodicity of the Aurora have been printed, General Lefroy, formerly director of the magnetic observatory in Toronto, Canada, has put at my disposal his large accumulation of observations in British America; also Prof. Joseph Henry, Secretary of the Smithsonian Institution, has placed in my hands the unpublished records of meteorology made in various parts of the United States, under the auspices of this institution, in accordance with the comprehensive plan of its accomplished Secretary. With these new and rich materials, and others not specified, to which I have had access since my first catalogue was printed, I have been induced to pause in the midst of my discussion of the *secular* periodicity of the aurora, and print a supplementary catalogue. I therefore postpone any remarks on this point until the next meeting of the Association, when I hope the new catalogue will be printed, and the investigation brought to a conclusion. However, the additional observations contained in the last catalogue, embracing, as they do, but a short period of years, will have less influence upon the question of the secular periodicity of the aurora than upon its yearly march from month to month, at Toronto, Quebec, Newfoundland, etc.; for which the observations in the first catalogue were limited to a small number of years.

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[*] Memoirs of the American Academy of Arts and Sciences. III. 44.

[†] Acta Soc. Sci: Fennic. etc. II. 302.

## NUMBER OF AURORAS OBSERVED EACH MONTH IN THE WESTERN HEMISPHERE.

| Place. | Jan. | Feb. | March. | April. | May. | June. | July. | August. | Sept. | October. | Nov. | Dec. | Total. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Newfoundland, | 9 | 20 | 14 | 16 | 11 | 5 | 13 | 13 | 16 | 19 | 5 | 10 | 151 |
| Quebec. | 6 | 25 | 14 | 24 | 7 | 10 | 13 | 10 | 19 | 21 | 13 | 7 | 169 |
| London. Canada, | 7 | 12 | 12 | 16 | 6 | 5 | 10 | 8 | 10 | 13 | 3 | 5 | 107 |
| Toronto, | 21 | 37 | 34 | 46 | 35 | 24 | 31 | 25 | 33 | 43 | 34 | 26 | 389 |
| Jakobshavn, | 27 | 24 | 17 | 1 | 0 | 0 | 0 | 0 | 17 | 28 | 34 | 37 | 185 |
| Gothaab. | 61 | 60 | 50 | 21 | 0 | 0 | 0 | 5 | 53 | 45 | 71 | 64 | 430 |
| New York State, | 76 | 89 | 110 | 132 | 89 | 80 | 106 | 125 | 141 | 117 | 75 | 65 | 1205 |
| New Haven, | 63 | 59 | 72 | 67 | 62 | 46 | 72 | 66 | 97 | 62 | 86 | 61 | 813 |
| Newberry. | 23 | 34 | 28 | 30 | 6 | 2 | 3 | 11 | 32 | 30 | 10 | 9 | 218 |
| Providence, | 15 | 17 | 14 | 13 | 18 | 7 | 10 | 7 | 21 | 21 | 14 | 3 | 160 |
| Burlington. | 8 | 6 | 9 | 8 | 12 | 5 | 6 | 3 | 8 | 3 | 3 | 3 | 74 |
| St. Martin. | 6 | 9 | 7 | 9 | 9 | 4 | 14 | 6 | 14 | 3 | 2 | 6 | 89 |
| Wilmington, | 6 | 1 | 4 | 1 | 5 | 5 | 6 | 5 | 10 | 3 | 3 | 4 | 53 |
| Worcester, | 19 | 13 | 27 | 25 | 10 | 9 | 12 | 19 | 30 | 22 | 15 | 11 | 212 |
| Salem. | 9 | 14 | 18 | 17 | 15 | 15 | 30 | 17 | 21 | 22 | 12 | 8 | 198 |
| Boston. | 2 | 4 | 1 | 5 | 1 | 2 | 2 | 1 | 6 | 2 | 6 | 4 | 36 |
| Cambridge. | 19 | 27 | 37 | 39 | 21 | 10 | 29 | 20 | 45 | 33 | 17 | 19 | 316 |
| Cambridge. | 17 | 31 | 46 | 33 | 24 | 26 | 44 | 40 | 49 | 32 | 31 | 17 | 390 |
| Aggregates, | 394 | 482 | 514 | 503 | 331 | 255 | 401 | 381 | 622 | 519 | 434 | 359 | 5195 |

## NUMBER OF AURORAS OBSERVED EACH MONTH IN THE EASTERN HEMISPHERE.

| Place. | Jan. | Feb. | March. | April. | May. | June. | July. | August. | Sept. | October. | Nov. | Dec. | Total. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Prague, | 6 | 4 | 4 | 6 | 6 | 1 | 2 | 3 | 4 | 7 | 3 | 1 | 47 |
| Ratisbon, | 1 | 3 | 9 | 9 | 6 | 7 | 2 | 4 | 2 | 8 | 3 | 0 | 54 |
| Holland, | 49 | 47 | 92 | 103 | 110 | 34 | 37 | 59 | 64 | 74 | 47 | 34 | 750 |
| Copenhagen, | 1 | 5 | 9 | 12 | 4 | 0 | 3 | 1 | 4 | 5 | 2 | 2 | 48 |
| Mannheim, | 18 | 12 | 33 | 32 | 13 | 8 | 12 | 16 | 28 | 18 | 16 | 10 | 216 |
| Scandinavia, | 40 | 30 | 38 | 11 | 0 | 0 | 0 | 4 | 28 | 49 | 47 | 41 | 288 |
| Sagan, | 25 | 14 | 34 | 40 | 8 | 2 | 3 | 8 | 22 | 39 | 31 | 14 | 240 |
| Spydberg, | 8 | 7 | 17 | 6 | 2 | 0 | 0 | 1 | 10 | 18 | 6 | 6 | 81 |
| Italy, | 4 | 9 | 21 | 5 | 3 | 4 | 6 | 7 | 7 | 12 | 3 | 7 | 88 |
| Wittemberg, | 8 | 12 | 13 | 7 | 3 | 0 | 2 | 11 | 8 | 16 | 5 | 6 | 91 |
| Franeker, | 20 | 15 | 41 | 23 | 16 | 6 | 8 | 15 | 30 | 30 | 13 | 14 | 231 |
| Montmorenci, | 8 | 13 | 26 | 18 | 14 | 6 | 9 | 11 | 27 | 20 | 11 | 5 | 168 |
| Carlsruhe, | 2 | 9 | 13 | 15 | 8 | 2 | 5 | 11 | 6 | 8 | 5 | 3 | 87 |
| Paris, | 4 | 5 | 12 | 4 | 20 | 5 | 6 | 10 | 15 | 11 | 12 | 4 | 108 |
| Berlin, | 21 | 37 | 55 | 48 | 39 | 2 | 10 | 10 | 22 | 45 | 29 | 13 | 331 |
| Upsal, | 85 | 131 | 152 | 75 | 7 | 2 | 4 | 72 | 126 | 146 | 109 | 109 | 1018 |
| Brussels, | 12 | 13 | 18 | 22 | 38 | 23 | 23 | 11 | 16 | 23 | 17 | 15 | 231 |
| St. Petersburg, | 70 | 100 | 179 | 152 | 42 | 18 | 15 | 62 | 145 | 146 | 83 | 79 | 1086 |
| Stockholm, | 27 | 34 | 50 | 56 | 13 | 0 | 0 | 19 | 44 | 39 | 34 | 25 | 341 |
| Christiania, | 46 | 61 | 75 | 60 | 3 | 0 | 1 | 35 | 78 | 65 | 55 | 55 | 534 |
| Dunse, | 33 | 20 | 18 | 18 | 3 | 0 | 2 | 14 | 43 | 34 | 30 | 23 | 238 |
| Makerstoun, | 22 | 26 | 28 | 16 | 6 | 0 | 0 | 7 | 16 | 29 | 23 | 11 | 184 |
| Plymouth, Engl., | 8 | 7 | 23 | 12 | 6 | 1 | 8 | 8 | 10 | 15 | 13 | 9 | 120 |
| Great Britain, | 21 | 19 | 23 | 12 | 3 | 2 | 1 | 3 | 35 | 23 | 21 | 22 | 185 |
| Kendall, &c., | 18 | 18 | 26 | 32 | 21 | 5 | 2 | 21 | 23 | 36 | 38 | 10 | 250 |
| Hammerfest, | 19 | 16 | 8 | 0 | 0 | 0 | 0 | 0 | 4 | 9 | 16 | 19 | 91 |
| Abo, &c., | 66 | 87 | 99 | 61 | 9 | 0 | 2 | 28 | 98 | 97 | 74 | 61 | 682 |
| Jena, | 2 | 9 | 4 | 10 | 4 | 2 | 4 | 8 | 14 | 15 | 6 | 6 | 84 |
| Aggregates, | 644 | 763 | 1120 | 865 | 407 | 125 | 167 | 459 | 929 | 1037 | 752 | 604 | 7872 |

### TIMES OF MAXIMA AND MINIMA ARRANGED GEOGRAPHICALLY.

| Place. | Max. | Min. | Max. | Min. | Number. | Years. | Authority. |
|---|---|---|---|---|---|---|---|
| Fort Reliance, | ? | ? | ? | ? | 196 | | Hough. |
| Jakobshaven, | ? | ? | ? | ? | 185 | 1840 – 1851 | Rudolph. |
| Gothaab, | ? | ? | ? | ? | 430 | 1841 – 1846 | Block. |
| Newfoundland, | Feb. | June | Oct. | ? | 151 | 1849 – 1851 | Lefroy. |
| Quebec, | Feb. | May | Oct. | Jan. | 169 | 1848 – 1851 | Lefroy. |
| London, Canada, | April | June | Oct. | ? | 107 | 1848 – 1851 | Lefroy. |
| St. Martin, | ? | June | Sept. ? | Nov. ? | 89 | 1853 – 1854 | Smallwood. |
| Toronto, | April | June | Oct. | Jan. | 369 | 1848 – 1851 | Lefroy. |
| Burlington, | ? | ? | ? | ? | 74 | 1852 – 1853 | Thompson. |
| Newberry, | Feb. | June | Sept. | Dec. | 218 | 1830 – 1862 | Johnson. |
| Salem, | March ? | June | Oct. ? | Dec. | 198 | 1786 – 1820 | Holyoke. |
| Providence. | Feb. | June | Sept. ? | Dec. | 160 | 1832 – 1860 | Caswell. |
| Boston, | ? | ? | ? | ? | 36 | 1818 – 1848 | Hale. |
| Cambridge, | March | June | Sept. | Dec.? | 706 | 1742 – 1864 | Lovering, &c. |
| Worcester, | March | June | Sept. | Dec. | 212 | 1839 – 1862 | Woodward, &c. |
| New Haven, | March | June | Sept. | Dec. | 813 | 1763 – 1854 | Herrick, &c. |
| New York State, | April | June | Sept. | Dec. | 1205 | 1826 – 1851 | Hough. |
| Wilmington, | ? | ? | ? | ? | 53 | 1827 – 1833 | Gibbon. |

## TIMES OF MAXIMA AND MINIMA ARRANGED GEOGRAPHICALLY.

| Place. | Max. | Min. | Max. | Min. | Number. | Authority. | Years. |
|---|---|---|---|---|---|---|---|
| Scandinavia, | ? | ? | ? | ? | 288 | Lottin, &c., | 1837 - 1840 |
| Abo, &c., | March | June | Sept. | Dec. | 682 | Hallström, | 1748 - 1843 |
| Helsingfors, | March | June | Sept. | Jan. | 30 | Argelander, | 1832 - 1837 |
| Spydberg, | March | June ? | Oct. | ? | 81 | Wilse, | 1784 - 1787 |
| Hammerfest, | ? | ? | ? | ? | 91 | Noodt, | 1850 - 1861 |
| Christiania, | March | June | Sept. | Jan. | 534 | Hansteen, | 1837 - 1853 |
| Stockholm, | April | June ? | Sept. | Dec. | 341 | Nicander, | 1783 - 1792 |
| St. Petersburg, | March | June | Oct. | Jan. | 1086 | Kraft, Euler, &c., | 1726 - 1861 |
| Upsal, | March | June | Oct. | Jan. | 1018 | Celsius, &c., | 1716 - 1762 |
| Dunse, | ? | June | Sept. | ? | 238 | Stevenson, | 1838 - 1847 |
| Makerstoun, | March | June ? | Oct. | Dec. | 184 | Broun, | 1843 - 1849 |
| Copenhagen, | April | June | Oct. | Jan, | 48 | Bugge, | 1782 - 1788 |
| Kendall, &c., | April | July | Nov. | Dec. | 250 | Dalton, | 1786 - 1793 |
| G. Britain, | March | July | Sept. | Jan ? | 185 | Dalton, | 1794 - 1834 |
| Berlin, | March | June | Oct. | Dec. | 331 | Kirch, Beguelin, | 1707 - 1789 |
| Leyden, Utrecht, &c., | May | June | Oct. | Dec. | 750 | Musschenbroek, | 1716 - 1744 |
| Franeker, | March | June | Sept. ? | Nov. | 231 | Van Swinden, | 1771 - 1781 |
| Jena, | ? | June | Oct. | Jan. | 84 | Zeissing, Succow, | 1770 - 1796 |
| Mannheim, | March | June | Sept, | Dec. | 216 | Hemmer, | 1781 - 1792 |
| Sagan, | April | June | Oct. | Dec. | 240 | Preus, | 1781 - 1792 |
| Brussels, | May | Aug. | Oct. | Jan. | 231 | Mann, Quetelet, | 1778 - 1851 |
| Plymouth, | March | June | Oct. | Jan. | 120 | Huxham, | 1728 - 1748 |
| Prague, | ? | June | Oct. | Dec. | 47 | Strnad, | 1782 - 1791 |
| Carlsruhe, | April | June | Aug. ? | Jan. | 87 | Eisenlohr, | 1779 - 1831 |
| Ratisbon, | April ? | July | Oct. | Dec. | 54 | Heinrich, | 1781 - 1791 |
| Paris, | March | June | Sept. | Dec ? | 108 | Cassini, Bouvard, | 1784 - 1842 |
| Montmorenci, | March | June | Sept. | Dec. | 168 | Cotte, | 1771 - 1805 |
| Wittemberg, | March | June | Oct. | ? | 91 | Weidler, | 1730 - 1751 |
| Italy, | March | May | Oct. | ? | 88 | Beccari, Zanotti, | 1727 - 1751 |

## NUMBER OF AURORAS ON EACH DAY OF THE YEAR.

| Day. | Jan. | Feb. | March. | April. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. | Total. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 34 | 29 | 36 | 33 | 28 | 12 | 18 | 14 | 28 | 33 | 30 | 30 | 325 |
| 2 | 32 | 35 | 42 | 42 | 29 | 14 | 18 | 18 | 25 | 39 | 33 | 36 | 363 |
| 3 | 35 | 34 | 34 | 36 | 16 | 12 | 15 | 17 | 29 | 45 | 32 | 31 | 336 |
| 4 | 28 | 33 | 35 | 38 | 23 | 11 | 12 | 19 | 26 | 37 | 33 | 35 | 330 |
| 5 | 25 | 24 | 38 | 30 | 19 | 14 | 15 | 8 | 31 | 37 | 32 | 34 | 307 |
| 6 | 32 | 34 | 39 | 37 | 19 | 13 | 7 | 17 | 34 | 35 | 35 | 34 | 336 |
| 7 | 22 | 36 | 29 | 40 | 21 | 15 | 18 | 9 | 33 | 38 | 34 | 41 | 336 |
| 8 | 33 | 27 | 34 | 30 | 15 | 9 | 10 | 10 | 33 | 44 | 32 | 37 | 314 |
| 9 | 34 | 36 | 40 | 38 | 16 | 12 | 14 | 11 | 36 | 39 | 34 | 27 | 337 |
| 10 | 29 | 37 | 36 | 36 | 15 | 15 | 14 | 20 | 42 | 31 | 30 | 37 | 342 |
| 11 | 34 | 41 | 33 | 36 | 15 | 8 | 13 | 18 | 30 | 28 | 35 | 25 | 316 |
| 12 | 37 | 35 | 42 | 44 | 19 | 13 | 13 | 19 | 38 | 38 | 34 | 38 | 370 |
| 13 | 42 | 30 | 42 | 34 | 19 | 12 | 13 | 16 | 40 | 33 | 43 | 40 | 364 |
| 14 | 28 | 32 | 46 | 41 | 21 | 13 | 8 | 26 | 30 | 39 | 40 | 35 | 359 |
| 15 | 26 | 36 | 42 | 40 | 13 | 11 | 11 | 17 | 43 | 36 | 37 | 41 | 353 |
| 16 | 28 | 42 | 48 | 35 | 17 | 12 | 11 | 20 | 30 | 36 | 32 | 34 | 345 |
| 17 | 39 | 38 | 43 | 32 | 23 | 11 | 3 | 26 | 48 | 35 | 41 | 41 | 380 |
| 18 | 32 | 44 | 44 | 36 | 15 | 8 | 10 | 16 | 37 | 35 | 42 | 42 | 361 |
| 19 | 30 | 36 | 43 | 35 | 11 | 9 | 12 | 25 | 40 | 40 | 48 | 33 | 362 |
| 20 | 34 | 36 | 42 | 37 | 17 | 8 | 13 | 21 | 37 | 39 | 31 | 37 | 352 |
| 21 | 32 | 35 | 35 | 28 | 12 | 7 | 10 | 32 | 33 | 36 | 33 | 29 | 322 |
| 22 | 29 | 43 | 36 | 23 | 18 | 8 | 7 | 32 | 44 | 41 | 31 | 36 | 348 |
| 23 | 30 | 40 | 38 | 24 | 18 | 4 | 12 | 24 | 33 | 42 | 33 | 29 | 327 |
| 24 | 28 | 37 | 30 | 30 | 14 | 9 | 12 | 22 | 52 | 38 | 28 | 26 | 326 |
| 25 | 30 | 26 | 40 | 19 | 10 | 9 | 14 | 25 | 41 | 38 | 29 | 27 | 308 |
| 26 | 24 | 40 | 46 | 19 | 11 | 10 | 7 | 26 | 39 | 35 | 30 | 33 | 320 |
| 27 | 35 | 42 | 37 | 25 | 10 | 9 | 16 | 27 | 41 | 48 | 33 | 25 | 348 |
| 28 | 35 | 38 | 43 | 16 | 12 | 12 | 15 | 25 | 38 | 36 | 29 | 35 | 334 |
| 29 | 33 | 7 | 44 | 19 | 15 | 10 | 13 | 35 | 32 | 40 | 29 | 30 | 307 |
| 30 | 33 |  | 45 | 23 | 16 | 11 | 8 | 31 | 41 | 30 | 24 | 35 | 297 |
| 31 | 28 |  | 33 |  | 14 |  | 16 | 32 |  | 33 |  | 35 | 201 |
| Total. | 971 | 1003 | 1215 | 956 | 521 | 321 | 378 | 658 | 1084 | 1154 | 1007 | 1048 | 10316 |

## 2. REMARKS ON METEOROLOGICAL RESULTS DEDUCED FROM THE NEW METHOD OF REGISTRATION. By G. W. HOUGH, of Albany, N. Y.

(ABSTRACT.)

A DEFINITE knowledge of the laws which govern atmospheric phenomena, we believe can only be attained by the study of continuous records. Isolated observations made two or three times each day, on temperature, pressure, etc., will never give us correct views regarding the changes continually taking place, or the manner in which they are brought about. Observations of this kind have been of great value in determining some of the more general laws of climate, but we believe nearly all the results, capable of being deduced from such data, have been attained. We must therefore look for a more complete and extensive system of observation for the deduction of the special laws governing atmospheric changes.

During the past two years there has been in successful operation at the Dudley Observatory, a registering and printing barometer, invented and first employed at this institution. This instrument gives a continuous record of the changes of atmospheric pressure, and prints, with type, the height of the barometer hourly. It also records the total motion of the barometrical column, or in other words the total amount of atmospheric disturbance; a result which has never before been attained. During the past year instruments of the same kind have been in operation at the Chamber of Commerce, New York City, and at Rutger's College, and also for a short time at Dartmouth College. The comparison of the continuous records made at these places has enabled us to deduce some interesting results.

The total motion of the barometrical column, for the year 1866, was 148.6 inches, — for summer 62.1 inches, and for winter 86.5 inches, — which is equivalent to removing the whole body of the atmosphere five times every year. The greatest motion was in the month of March, the least in June; in the former case 19 inches, in the latter 7 inches. There is apparently but little difference in the amount of the motion for the different months from May to September, and the same thing may be said of the remaining months from October to April. This result is as might have been anticipated, since, during the summer, the weather is more uniform and not liable to so great changes, while during the spring and winter the atmosphere is almost constantly in a state of agitation.

It was stated, at the meeting of last year, that we believed great storms were preceded by a large number of small pulsations in the atmosphere, and that these pulsations were manifest in the barometer by the distance travelled by the column of mercury in any interval, as compared with the absolute change of height in the same time.

For the purpose of illustration, we will suppose the barometer has fallen 0.5 in. in 24 hours. Now, if in passing over this distance there have been no pulsations, the total motion will only amount to 0.5 in. But if on the contrary, the column has been in a state of agitation, the whole distance travelled by the mercury in falling 0.5 in. may amount to two or even three inches.

Hence we conclude that the *total amount* of atmospheric disturbance, as indicated by the motion of the barometrical column, is intimately connected with the state of the weather, the disturbance usually preceding great storms of wind, or heavy falls of rain or snow. During the year 1866, there were eight days on which the disturbance amounted to more than one inch, for the total motion of the column, and on one day the motion was over two inches. This excessive disturbance on December 27th was followed by a gale of wind, and on the next day by a fall of 16 inches of snow. And, generally without exception, these excessive disturbances were followed either by wind, or a fall of water. The storm of December 27th and 28th will be remembered by every one; it was a great storm, extending both east and west. Previous to this storm the height of the barometer only changed three-tenths of an inch, but the *total motion* was more than *seven* times as great, going to prove that the disturbance is of more importance in predicting storms than the changes of barometrical height.

The continuous record of the barometer gives us at a glance a general history of the weather. In fact, so uniform are the indications, that from an inspection of the curves, together with the records of the total motion, the direction and approximate force of the wind and the fall of rain can be determined with considerable precision. At Albany the barometer almost invariably rises under a west wind, and falls under a south wind owing, perhaps, to the influence of the valleys of the Mohawk and Hudson.

It has long been known that the barometer has a diurnal variation, due, we presume, almost entirely to temperature. From the monthly records of the past two years, we have deduced the diurnal variation. It is found that in the mean for the year, the barometer is at its mean height four times each day; viz., at noon, 8½ P. M., 1 A. M., and 4½ A. M.

The following are the times of Maxima and Minima for 1866.

| | MIN. | MAX. | MIN. | MAX. |
|---|---|---|---|---|
| Year | 4 P. M. | 10 P. M. | 3 A. M. | 10 A. M. |
| Spring | 3 " | 11 " | 3 " | 8 " |
| Summer | 6 " | 12 " | 3 " | 9 " |
| Autumn | 4 " | 10 " | 3 " | 10 " |
| Winter | 8 " | 10 " | 8 " | 10 " |

It appears from these results that the second minimum is constant for the year. The principal maximum occurs earlier, and the principal minimum later, in summer than in winter.

The daily amplitude, or difference between the principal maximum and minimum, for the year 1866, was found to be 0.063 in.

Atmospheric pressure is generally propagated from west to east, but such is not invariably the case. There is but little difference in the time at which the barometer reaches the highest and lowest points at New York and Albany, in fact, generally the curves are essentially identical. The examination of a large number of records appears, however, to indicate that, when the barometer is falling, it reaches the lowest point soonest in New York, and, when rising, it reaches the highest point soonest in Albany.

# B. NATURAL HISTORY.

## I. GEOLOGY AND MINERALOGY.

### 1. DEPRESSION OF THE OCEAN DURING THE ICE PERIOD. By CHARLES WHITTLESEY, of Cleveland, Ohio.

IT is a well settled truth in geology, that soon after the era of the Pliocene tertiary, a large portion, of the earth around the poles was coated with ice. It is not well settled to what this depression of temperature was due; but it will probably be found to be owing to astronomical changes, during which the angle between the ecliptic and the equator was different from what it is at present.

I do not propose to examine this question, at this time, but to show that there must have been, during the glacial period, a material depression of the surface of the ocean.

The land in the Northern Hemisphere bears abundant proofs of submergence towards the close of this period, up to elevations that are now 2,000 feet above tide-waters. Whether this submergence was, due to a rise of the waters, or to a subsidence of the land, I do not propose to discuss. The change I wish to present to your consideration is one which must have taken place while the ice period was coming on and which must have been occasioned by a depression of the waters.

Accumulations of ice and *névé* can only occur on land by deposition, in the form of rain and snow, which becomes congealed. The ultimate source of this deposition is evaporation from the open surface of the sea. Inland lakes, rivers, swamps, and low lands furnish vapor to the clouds; but all fresh water basins receive their supply originally from the ocean.

The water line, or level of the sea, remains fixed, only because the amount of water taken up in vapor from its surface is returned to it through the rivers of the globe. If the water deposition on the surface of the land is not returned to the sea, it must be subtracted from the mass of the common reservoir.

The era of ice came on by a slow but regular decrease of temperature. At the present time, the area of perpetual ice is small in comparison with the entire surface of the earth; but in the glacial epoch it was much larger. Let us imagine a depression of temperature to occur now, throughout the regions towards the poles. A loss of one degree of heat (Fahrenheit) annually would cause the snow line to descend 300 feet per year, thus enlarging the area of perpetual congelation. Around the base of all high mountain ranges, all the territory 300 feet below the previous snow line would become a retaining surface, no longer giving back its depositions to the sea. Rivers would continually become shorter and smaller. The inland lakes would, in process of time, become ice-bound, and, as the continental masses accumulated, they would encroach upon the ocean itself.

In the central portions of British North America and Asia, this accumulation would attain during a long period of time a great thickness. I think the observations show that in all ice masses there is a gradual but resistless outward motion. They would not only crowd into the basins of the great lakes, but into the bays, straits, and minor seas, connecting with the ocean. The Arctic Sea would be very much diminished in extent, and the sea of Okhotsk, of Kamtchatka, Hudson's Bay, Baffin's Bay, and the Baltic, would eventually be filled up and become ice-fields, from which evaporation would measurably cease.

On the coasts of Russian America, of Labrador, Greenland, Iceland, Norway, and Siberia, the continents would constantly gain upon the sea, so as eventually to connect Europe, America, and Asia, along the Arctic Circle.

The Antarctic Continent, now occupying about 10 degrees of latitude around the southern pole, would also increase in size towards the equator and connect with Terra del Fuego, where glaciers still exist. The glacier fields of the Andes would enlarge towards the south, and join with those of Patagonia. Those of the Alps pushing northward over Switzerland, across the chain of the Jura, would meet those of Scandinavia in Central Europe. In North America there are existing glaciers on the Rocky Mountains as far south as latitude 51° north, and it is reported that Bierstadt discovered one as low as latitude 45°, of which he has given a striking picture, from sketches made on the spot.

A projecting tongue of the North American ice field would project southerly along the Rocky Mountain range towards New Mexico and perhaps into Mexico proper.

If the area of this immense field of congelation could be determined, its extent, compared with the remaining water field of the earth's surface, being known, the depression of the waters by evaporation could also be determined. To obtain the absolute depression, it is further necessary to know the duration of the ice period or the average thickness of the ice over the area of congelation.

Geologists have not yet determined accurately the limits of glacial action even in the Northern Hemisphere. In Central Asia those limits are quite conjectural. The tendency of the observations now going on is to enlarge the extent of the ancient ice-fields.

After an examination of the ancient ice areas in North America, Europe, and Asia, I regard them as equal to *one-fifth* the present land surface of the Northern Hemisphere. The enlargement of the continental spaces over the adjacent seas, including the Antarctic Continent, I assume to be as much more. If this assumption is correct, there was a period when *one-fifth* of the land of the globe presented a congealed surface, and the remainder an evaporating surface. Of this evaporating surface, however, those parts which were then land, not covered with ice, derived their water of deposition from the ocean, circumscribed in the manner I have indicated.

The dry land of all the continents is now estimated to be, in reference to the ocean, as *one* to *three*, the land embracing one-fourth and the water three-fourths of the surface of the globe; or as thirty-seven millions of square miles is to one hundred and eleven millions. Two-fifths of thirty-seven millions is one-tenth of the surface of the earth, and about fifteen millions of square miles.

We cannot, at present, fix the average thickness of the ice covering as satisfactory as we can its extent. In New England, it does not appear to have reached the tops of all the mountains, but only a height of four thousand three hundred to five thousand three hundred feet. Over the region of the great Lakes, the glacial etchings upon the rocks extend to the summits of the country, which are, however, not more than two thousand feet in elevation. The ice covering must have exceeded this height by several hundred feet.

All the country around Hudson's Bay, the valleys of the Copper Mine, the McKenzie and the Saskatchawan Rivers, is a rocky plateau, nowhere rising above two thousand feet, until the base of the Rocky Mountains is reached.

In Northern Asia, there are still larger areas which are destitute of mountains. Over these level spaces the accumulation must have been heavier and of more uniform thickness than in more elevated and broken regions. Dr. Hayes penetrated the great mer de glace of Greenland, — a distance of seventy miles. At that distance, directly interior, it had an elevation of five thousand feet, presenting a smooth surface covered with snow. This is the largest ice field of the present era, known to us in the Northern Hemisphere; covering about four hundred thousand square miles. It is probably not an exaggerated estimate of this mass of ice, to regard it as equal to eighteen hundred feet of water over the same area, which, spread suddenly over the surface of the ocean, would raise it between three and four feet.

The Antarctic Continent is much larger than Greenland, and the ice covering is probably thicker. It must embrace from one million to one million five hundred thousand square miles. Its sudden liquefaction would give to the sea an elevation of about *twelve* feet.

In case the glacier regions of the Alps, of Arctic America, Patagonia, the Himalayas, and Arctic Asia should suddenly become warm, and the ice accumulations of thousands of centuries be reduced to water, seeking the sea through natural channels, nearly two hundred thousand square miles more of congealed matter would be returned to the ocean in a liquid form.

The density of the ice covering is another undetermined element. As compared with salt water, the icebergs of the north vary in weight or specific gravity from one-eighth to one-sixth. Their age, the pressure to which they have been subjected, and the length of time they have been afloat, each has its effect upon the solidity of the mass.

Assuming a specific gravity for solid ice of 0.90 of fresh water, an average thickness of two thousand feet represents about eighteen hundred feet of water spread over the same area. This body of water covering *one-tenth* of the surface of the earth, evenly distributed over the remaining nine-tenths, is equal to about one hundred and ninety feet. The same quantity abstracted from an ocean, covering only *nine-tenths* of the globe, would depress the level a greater number of feet; because the mass would diminish as its surface should be lowered. Besides, from the area of evaporation there should be deducted the land surface of that period, which, if it bore the same relation to the sea as it does now, would be, on the basis of my calculations, twenty-two millions of square miles to be taken out of one hundred and eleven millions. The open sea would be then restricted to less than ninety millions of miles, perhaps to not more than one-half the surface of the globe.

From all these considerations, at the period of greatest cold, the depression of the ocean level should be, at least, three hundred and fifty or four hundred feet. As the waters retired, the configuration of all the continents would change; groups of islands, like the West Indies, would unite, forming a smaller number of islands, but of larger area; new points would appear above the ocean level, and large shoals, like those of Newfoundland, become dry land. On these newly exposed surfaces, the temperature constantly falling, and ice and snow accumulating, the general reign of cold would be accelerated. The equilibrium between the warm and fluid portions of the earth and the solid and cold portions being destroyed, the difference in favor of the frigid portions would go on increasing until checked by a return to the previous astronomical status. The belt, or zone, of temperate climate along the equator would be contracted as the frozen zones were enlarged.

When the epoch of ice reached its maximum, the return to the previous condition of the earth's surface must have been gradual. The surface of the ocean would rise; and in case a period of higher temperature than the present succeeded the ice period, the sea level must have been higher than now.

As the stability of the ocean level depends upon such slight variations of terrestrial temperature, it is remarkable that it should be so well fixed. It must be that there are compensations in nature to preserve this stability.

Prof. Hall has long advocated the theory that heavy accumulations of transported materials, at the bottom of the sea, will eventually settle by their own weight. In that case a corresponding rise should take place in some adjacent region. If this position is a sound one, heavy accumulations of ice should produce the same results. There is some evidence, now available, to confirm this theory. The coast of Greenland is reported to be sinking, and that of Newfoundland to be rising.

During the ice period, a material portion of the mass of the globe was transferred from the equatorial seas in the form of vapor, and accumulated towards the poles, along and outside of the Arctic circles. Unless there is a mode of compensation, the figure of the earth was somewhat changed by this transfer. Its oblateness would become less, and its period of diurnal revolution would be altered.

The large, level regions in British America, east of the Rocky Mountains, would be the seat of a deposition of rain, forming ice, *névé* and snow, of great thickness, as is seen in Greenland now; only the accumulation would be as much heavier as the area is larger.

The motion which occurs in all ice fields towards the sea, or towards the thawing edges, is so slow as to require extremely long periods of time for their destruction. During this epoch, a new burden rested upon the earth, along a belt corresponding nearly with the Arctic and Antarctic Circles, rising from three thousand to six thousand feet. A gradual settling of these regions may have occurred from this cause. In case this position will bear investigation and is a true one, we shall have a much better explanation of the drift plateaus, ridges, and terraces of the quaternary period, which exhibit oscillations of level. A movement of elevation only is not sufficient. They involve changes of level in both directions, alternately up and down, of which we have not sufficient proof in the sudden upheavals and depressions of the rocky strata at that epoch. On Lake Ontario we have marine clays in the same present horizon with fresh water clays on Lake Erie, belonging to the drift period. If the interior of the continent went down, the natural result would be a simultaneous rising of the adjacent coast, bringing up the marine deposits.

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## 2. Abstract of Remarks upon the Occurrence of Iron in Masses. By Charles Whittlesey, of Cleveland, Ohio.

I do not propose to go into local details concerning the occurrence of masses of iron ore, with the exception of the great belt of hematite ores, extending from the lower Susquehanna, in Pennsylvania, northeasterly through New Jersey, New York, Connecticut, Massachusetts, and nearly through Vermont; neither shall I speak of the ores of the coal series, which occur in thin bands and not in masses.

On this general map of the United States and of Canada, I have colored the important iron centres black, but the scale is too limited to represent their form and extent in proper proportions. The first mountains of iron ore which attracted attention in this country were those of Missouri, about eighty miles south of St. Louis. Here the iron knobs, masses, and mountains appear, like the degraded edges of heavy ferruginous strata, in metamorphic beds, which have a porphyritic aspect. The ore is nearly pure specular oxide, in inexhaustible quantities; although the territory over which it is found is much less than in Michigan.

About five hundred miles north of the iron mountains of Missouri, on the waters of Lake Superior, occur the iron mountains of Michigan and Wisconsin. Those in the latter State occupy a belt about thirty miles in length, extending south westerly from the boundary on Montreal River, at a distance of ten to twenty miles from the lake. This ore is *wholly magnetic*, and occurs as a stratum, in a belt of stratified azoic quartz, dipping north-westerly at a high angle beneath the copper-bearing trap. It is fine-grained, black, frequently laminated, in plates with sharp edges, free of sulphur, phosphorus, arsenic, or other chemical impurities. The quantity is inexhaustible, — probably the accompanying rocks are metamorphic. They are almost entirely composed of silex, or silex and hornblende. The order of succession downwards is

1st. *Potsdam Sandstone*, of great thickness, at least ten thousand feet, dipping north-westerly at a high angle of seventy to ninety degrees beneath Lake Superior.

2d. *Copper-bearing trap*, a continuation of the Point Kewenaw Range, dipping conformably under the sandstone.

3d. Rocks of a trappose cast externally; but the analyses show no relation to trap, highly crystalline, red, blue, and black, dip conformable to the superior beds, but not as steep; thickness two to two and a half miles.

4th. *Quartz beds*, conformable and often slaty; thickness, half a mile; color white, gray, blue, and black; a band of magnetic ore near the centre, but not everywhere workable.

5th. *Granites and Sienites* of Central Wisconsin. No crystalline limestone has yet been discovered in the formations here noticed.

It is about one hundred and ten miles to the eastward of this iron belt to the exposures of iron slates, on the head waters of the Menominee River, near the Twin Falls, on the boundary between Michigan and Wisconsin. Here ferruginous masses form an important portion of the azoic rocks. They are both magnetic and specular. The adjacent rocks are siliceous slates, red, gray, dun, and black, all containing iron. There are hornblende slates and flags, and bands of blue, gray red, and variegated marble.

Proceeding north-easterly from the Menominee towards Marquette, the rocks become more trappose, and the iron ore, which is principally specular, but sometimes magnetic, becomes less slaty and more massive. The iron district is irregular in form, the longest, or east and west diameter, being about one hundred miles, and the north and south fifty miles in length. Heavy beds of quartz and dolomite characterize this region; but there cannot be traced in it the regular stratification of the Montreal and Bad River country. Both the quartz and the marble constitute immense elongated, flattened, and crooked bunches, not extending through the region as a connected system. In the easterly part of this great iron-producing field, nearest to Marquette, the trap ranges, and their huge bunches of ore, partake of the same form and irregularity. The field is known as part of the azoic series, in the Reports of Foster and Whitney, embracing, in addition to the marbles and siliceous slates, some micaceous schists and argillaceous and hornblende slates. It is bounded on the north and south by mountains of sienite and granite, having enclosed masses of hornblende rock, and occasionally dykes.

In the Canadian Reports, the Azoic system of Foster and Whitney is regarded as metamorphic, and divided between the Huronian and Laurentian formations.

Adjacent to the masses of ore hitherto wrought, is a rock which the miners call "greenstone," generally a homogeneous, but sometimes slaty, soft, light green rock, forming mountain ridges, the analysis of which corresponds with trap. It contains a large per cent. of oxide of iron, and passes gradually into workable ore. There is no regularity of dip among these greenstone ridges, nor in the included ore beds, nor are they continuous or strata-like in the direction of the ridges, but only more elongated in that direction. The ore masses are not separated by planes of division from the adjacent rocks. All of the rocks, composing the iron-bearing series, extend easterly into the Lake, at Marquette; but no workable masses of ore have been found nearer to navigable water than fourteen miles. A railway extends about thirty-five miles into the region to Matchigamni Lake, without reaching its central portions. The supply is incalculably large; and its present importance is shown by the amount of ore shipped, or manufactured in 1867, which exceeds four hundred and fifty thousand gross tons. Of this, about three-fourths is specular, the remainder mostly hematite, forming a portion of almost every mine, and a few thousand tons of magnetite.

In the Laurentian system of Canada there are several remarkable deposits of iron ore, principally magnetic and crystalline. They are found on Lake Nepissing, north of Lake Huron, at Bay St. Paul, on the St. Lawrence, where the ore contains a large per cent. of titanic acid, and on the Rideau Canal, at Mud Lake, midway between Kingston and Ottawa. But the largest masses, approaching those of Michigan and Missouri in size, are at Marmora, near the gold field of Madoc, on the waters discharging into the Bay of Quintè. None of these mines have as yet furnished much ore to commerce, owing, probably, to the low state of iron manufacture in Canada.

The rocks composing the mountainous region of Northern New York are outliers of the great Laurentian field in Canada. Here, over a space nearly one hundred miles in diameter, iron ore, in general of the magnetic variety, is everywhere found. It occurs in veins or beds, or both, different explorers using these terms interchangeably. The ore is not found in masses like those at Marquette. Large numbers of the deposits are, however, thick enough to be wrought. It is only the rough, impracticable character of the country which has prevented the vast iron region of the Adirondack from being penetrated by railroads, and exposing numberless mines. At present, only the eastern edge of the region, which approaches within a few miles of Lake Champlain, is accessible. The ore is even yet brought to navigation by teams over rough roads, from whence it is shipped to the furnaces on the waters of the Hudson. A few thousand tons are annually transported to the works in Ohio, at and near Cleveland. It is generally crystalline, easily crushed, makes a tough metal, and is particularly good for lining to puddling furnaces. Besides the micaceous and quartzose beds of the Northern Laurentian, the New York portion of the formation, especially the south-eastern portion of it, embraces hypersthene rocks in great force; but the limestones are wanting. On the waters of the Oswegatchie, near the junction of the overlying Potsdam, in St. Lawrence County, there are large irregular deposits of red ochrey hematite. In connection with these hematites are elongated masses of crystalline limestone, such as accompany the hematite beds of the Taconic range in Connecticut and Massachusetts. After penetrating from the hematites, on the Oswegatchie, a short distance eastward, into the Laurentian field, the black, rich, magnetic ores of the Adirondack are met with, having the usual form of beds, or veins, perhaps both. Wherever this wild region has been penetrated, whether by hunters, fisherman, or explorers, their reports agree, that iron ore exists in quantities literally inexhaustible.

Thus the notable deposits of magnetic and specular iron ore are found associated with the quartz rocks, hornblende rocks, porphyry, micaceous schists, and dolomitic marbles, composing the most ancient metamorphic series. If the metamorphism of the Laurentian and Huronian formations shall be regarded as an established geological fact, the separation of the oxides of iron from these rocks into veins, beds, and masses can be easily accounted for. All sedimentary strata contain the oxides of iron; and any agent powerful enough to change the crystalline form of rock would bring about a concentration of their minerals. Metals, their oxides and salts, possess an inherent quality of segregation. Whenever the condition of the enclosing strata is such as to allow of motion among particles having the affinity of segregation, they must obey this affinity and become more concentrated. The points about which the concentration takes place are determined by the accidents of fracture, change of density, divisional planes, and even by the presence of fossils.

There are very important deposits of iron oxide in the sedimentary rocks of the United States that do not come under the head of masses. Of these, the most persistent and wide-spread is that belonging to the Clinton group of limerocks which is generally oolitic in structure. In Wayne County, New York, there is a remarkable outcrop of this ore about twenty miles in length. In Wisconsin it has been opened in Dodge and Brown Counties, several feet in thickness. On the Upper Juniata, in Pennsylvania, and thence south-westerly, in the same formation through Maryland into Virginia, it has been discovered and worked at numerous points. It exists in force in the same geological horizon in Eastern Tennessee, extending southerly into Alabama, under the name of "dyestone ore." As a general rule, it produces a soft iron of superior quality, and is very easily reduced in the furnace.

But the iron-bearing belt, which is best known to manufacturers because it has been longest and most extensively wrought, belongs to the Green Mountain range of Vermont, and extends thence southerly through Massachusetts, the north-western corner of Connecticut, and Eastern New York, crossing the Hudson River near Fishkill, thence across the north-western part of New Jersey into Pennsylvania, and across the Susquehanna into Maryland, — a distance of, at least, three hundred and fifty miles. A large part of this range is now regarded as a part of the lower silurian system, in a highly metamorphosed condition.

After crossing the Hudson, the hematites diminish in quantity, being partially replaced towards the south-west by magnetic ores, or by beds, veins, and masses containing both varieties. The same metamorphic belt, existing in very different degrees of change, which extends southerly through Virginia and North Carolina into South Carolina, near King's Mountain, carries everywhere deposits of iron ore, but more magnetic than hematite. In this quarter, no great mines have been opened; not from the lack of ore, but from the absence of enterprise. The most southerly mine, developed on a large scale, is the famous Cornwall ore bed, in Berk's County, Pennsylvania. According to Mr. Lesley, it belongs to the Upper Potsdam. The ore is principally hematite, with pyrites and some magnetite. There are trap dykes intersecting the mass, to which, no doubt, some of the metamorphism and segregation is due. Similar masses are well developed in the same horizon in Buck's and Lancaster Counties at Chestnut Hill, and at the Warwick mines.

In order to compare the mode of occurrence here with that in Connecticut and Massachusetts, I quote from Lesley's exhaustive work on the Iron Manufacture of the United States, p. 560, — a local section made by Prof. Rogers. The mine, near Safe Harbor, on the Susquehanna, had, in 1858, reached a depth of one hundred and thirty-eight feet. It is situated between Potsdam slates and magnesian limestone, F. 2, dip 40°.

| | THICKNESS. |
|---|---|
| 1. Mica slate, | 14 feet. |
| 2. Sandy ore, | not given. |
| 3. Brown hematite ore, solid, | 6 feet. |
| 4. Mica slate, | 10 " |
| 5. Blue talc slate, | 30 " |

It is to these remarkable hematite bunches, extending from the Susquehanna north-easterly to and across the Hudson, and thence to the Otter River, in Vermont, that I propose to devote the remainder of this paper. There has been a great diversity of opinion among geologists on the origin of these deposits. By hastily grouping their leading characteristics, light will be thrown upon this question. A group of hematite mines about Saegersville and Trouton, in Lehigh County, Pa., which have been long wrought, are in close relations with lower silurian limerock. This association with limestone, generally crystalline, is the marked feature of the massive hematites. The extensive mines near Allentown and Bethlehem, Pa., are also in contact with limestone beds of the same age, constituting in an altered condition, the " Quebec Group " of Canada. On the same geological range, travelling to the north-east, in New Jersey, near the line of New York, at the base of Pochunk Mountain, is a repetition of the red hematite masses. Its dip is steep to the east-south-east, lying between beds of gneiss, altered felspar or kaolin, and crystalline limestone, belonging to Formation No. 2.

The Townsend mine, at Cornwall, Orange County, N. Y., is in the same formation. At Westchester, N. Y., the ore is alternated with layers of clay (altered felspar) and sand. At the Prescott Bank, in Hillsdale, crystalline limestone forms (according to Prof. Hodge) the base of the mine. The Fishkill mine is between strata of limerock. F. 3 (Hodge). Its section is thus: ore, with a band of slate, fourteen feet; clay, fifteen feet; ore, six feet. In Columbia and Duchess Counties, N. Y., the ore lies generally at the junction of the Potsdam and calciferous (F. 2), resting on limerock, with mica slate above. The dip is twenty to sixty east (Mather). The Amenia banks are between talcose, or talco-micaceous schists and limestone.

In Dover, N. Y., six miles west of the Housatonic River, the nearest visible rocks are the mica slate (Hitchcock).

Proceeding northerly, there are old openings at Kent, on the Connecticut and New York line, where the foot-wall is micaceous gneiss, then ore and green earth twelve feet thick; dip easterly, 60° to 80°. At Indian Pond in Sharon, Conn., just south of the Taconic mountain, is the same ore, a little flatter, the dip being about 45° east.

The most ancient and the best developed of the iron mines of this range are at Salisbury, Connecticut, a township situated in the north-west corner of the State, the west line abutting on New York, and the north line on Massachusetts. Iron was made from the " Old Ore Hill " Bank as early as 1748. At present the principal excavations are known as Chatfield's, the " Old Ore Hill," and Davis'. In Mr. Lesley's view, the Chatfield Bank is on or near the crown of an undulation, the dip being to the east about 50°.

The Old Ore Hill Bank is but a short distance north of Chatfield's, and the exposure is more extensive. It rests on quartz bunches, which pass into the micaceous, or talco-micaceous mass of the Taconic mountain, that rises rapidly to the north, attaining the general altitude of the Green Mountain range, of which it forms a part. The strike is north-east; the dip 50° to 60° south-easterly. These layers are not strictly conformable to the face of the micaceous portion, but a little flatter. When I examined it in 1858, the space then worked by the miners, measured across the beds, was seventy feet wide, in which there were visible four warped beds composed of fibrous quartz, and a talcose material which the workmen call "white horse." These corrugated beds were gray, white, and red; the fibres, or needle-like crystals of the quartz, standing at right angles to the surface of the layer. The space between the strata was occupied by kaolin, clay, ochre, and hematite. Much of the ore is crystallized in bunches and geodes, the crystals radiating from the centres, or other surfaces, which are polished, and show brilliant black and iridiscent colors. There are crystals of felspar in the ore, which lies not in flat bands, but in bunches, surrounded by felspathic clay that passes into ochre. Along the eastern foot of the mountain to the north-east are several openings, the principal of which is the "Davis Mine," about four miles from the Old Ore Hill, and a mile south-west of the centre of Salisbury. Here are the same variegated layers of talcose, aluminous, and siliceous matter, also warped and twisted, having the same general inclination to the south-east, varying from 20° to 40°. As at the other mines of the hematite series, the ore is covered with a heavy deposit of coarse drift, which conceals the ore sometimes to a depth of twenty or thirty feet, and must be carted away as the work progresses, causing a heavy and constant expense for dead work. On the side next the mountain there is here a bed of crystalline limestone which is not conformable to the iron-bearing layers, but dips north-west at an angle of 45°. This is doubtless due to local disturbance. On the east the valley of the Housatonic is occupied by the same limestone in great force. According to Mr. Percival, the ore lies between this metamorphic limerock (Formation M) and the talco-mica slate.

On the west side of the Taconic mountain in New York, near Middleton Station, on the Harlem railway, two miles west of Ore Hill, a mine has been wrought for many years for the use of Dakin's furnace. This is partly around the mountain to the north and west, and although the iron-bearing layers are somewhat confused, their dip is to the east very sharp, or 70° to 80°, thus pitching under the mountain and the Old Ore Hill. The dolomite, "white horse," and mica-slate still form the body of the strata, with felspathic clay, ochre, and iron ore.

Below is a bed of limerock of a dark color. Travelling northward along the western base of the range, near the Massachusetts line, at Boston Corners, the same ore is mined to a limited extent. President Hitchcock (Mass. Reports, p. 573) says the limestone here alternates with argillaceous slate, containing organic remains; the whole dipping rapidly, say 80° to 90°, to the east. At Copake, still farther north, the ore is interstratified with mica-slate above the ore, and limerock below, all pitching eastward beneath the mountain.

Before noticing the hematite deposits farther north, in Massachusetts and Vermont, I will repeat President Hitchcock's general sections of the rocks of the Green Mountain range in Massachusetts.

| East and west profile near the south line of Massachusetts. Dip east 60° to 90°. | East and west profile near Richmond, Mass. Dip east 60° to 80°. | East and west profile near the north line of Mass., Saddle Mountain. Dip east 50° to 80° |
|---|---|---|
| 1. Argillaceous slate in New York. | 1. Argillaceous slate, New York. | 1. Argillaceous slate, New York. |
| 2. Blue limerock. | 2. Limerock, bluish color less crystalline than No. 4 slate line. | 2. Wanting. |
| 3. Talco-micaceous schists, Mount Everett. | 3. Talco-micaceous schist, Lenox. | 3. Talco-micaceous schist, slate line. |
| 4. Crystalline dolomite, Sheffield, 10 to 12 ms. broad. | 4. Crystalline dolomite. | 4. Crystalline dolomite, Williamstown. |
| 5. Micaceous schist. | 5. Wanting. | 5. Talco-micaceous schist, Saddle Mountain. |
| 6. Wanting. | 6. " | 6. Crystalline limerock, North Adams. |
| 7. Quartz rock (Potsdam)? | 7. Quartz rock. | |
| 8. Crystalline limerock, N. Marlboro. | 8. Gneiss. | |

The ore beds are thus seen to be everywhere conformable to the other strata of the range. At West Stockbridge, Lenox, Richmond, and Great Barrington, in Massachusetts, the best developed mines are found at the junction of the micaceous bed, No. 3, and the dolomite, No. 4, which is the position of the Chatfield Old Ore Hill, and Dorr's Banks, in Salisbury. The ore at Dakin's, Boston Corners, and Copake, in New York, skirts the edge of the blue limerock, No. 2, and corresponds with the position of the Vermont mines.

Through the Salisbury mines the section is the same as Nos. 1, 2, 3, 4, and 5 of the most southerly profile in Massachusetts, the broad belt of crystalline limestone, No. 4, filling the valley of the Housatonic. It carries small crystals of sulphuret of iron, and also the protoxide of iron, amounting, according to President Hitchcock, to *four and one half per cent.* In general, the limestone of the Green Mountain range shows disseminated iron. At Salisbury and Great Barrington there are limited quantities of pyrites in the mines.

The blue limerock, No. 2, and the white, No. 4, extend northerly into Vermont; but heavy masses of ore have not been developed in them in the north-western part of Massachusetts.

After the slate line is passed, along the western base of the range in Vermont, the hematites reappear in large bodies, having the same geological relations as farther south, — the dip of the strata being uniformly east. There are workable mines at, or near, Bennington, Dorset, Chittendon, Pittsford, and Wallingford. At North Dorset, according to the late Prof. C. B. Adams, the layers of clay, ochre, and hematite, of the Laconic Mountain, are repeated with an inclination 12° east. At Pittsford they are steeper, or 55° to 60° inclined in the same direction.

The Chittendon mines, in Rutland County, present the same bands of quartz, clay, ochre, and hematite, in contact with talcose slate and limestone, pitching rapidly east (Vermont Reports). This ore carries a large proportion of manganese like many other mines of the Green Mountain and Taconic range. At Wallingford, the iron belt is two hundred and fifty to three hundred feet thick, resting upon limestone, with a dip to the east of 60°. The Brandon mine, in Rutland County, which has become famous on account of its lignites, and recent vegetable fossils, presents no exception to the system of hematite beds. I have dwelt upon the local sections of these mines, because it is not many years since they were considered as belonging to the tertiary. The information we now have makes them, beyond controversy, a part of the Green Mountain system, which is generally considered as the metamorphosed condition of those level silurian beds next above the Potsdam. The iron ores thus belong to the upper part of the "Quebec Group" and the lower portion of the "Trenton Group" of the Canadian Reports. Those eminent geologists, who first studied the hematites of this range, were quite unanimous in regarding them as the result of very recent geological changes, probably because the ore is a hydrate, and its surface associations are drift gravel and clays. The singular discovery of fossils of the present era, in this ore at Brandon, gave new strength to this theory. But more recent investigations show that hematite is not necessarily of sedimentary origin. Hydrates are common in rocks which are still regarded as igneous. Throughout the masses of specular ore, in Marquette County, Michigan, are large bunches of hematite, so extensive as to form a material part of the ore now mined. Hematites are too extensive and too far below the surface to admit a general theory of recent and local changes.

Depth has disclosed no modifications in the ores of the Green Mountains; and since these beds were subject, on account of their softness, to great destruction by the drift forces, the bottom of the present mines, in some places more than one hundred feet down in ore, must be regarded as much more than that distance below the original surface. The causes which concentrated the ore along this line of several hundred miles, everywhere in contact with metamorphic limestone, must have been universal and not local. Iron in some form exists in all rocks. The limestone beds of the Clinton and the Hudson River group are charged with it, especially near their junction, where the oolitic or dye-stone ore is generally found. If these strata should undergo a molecular change, whatever the agent might be, it must act, at the same time, as a concentrator of their mineral contents. In this action, limestone seems to be an almost necessary medium or facilitator. The belief in a wide-spread, almost an universal, metamorphism of the rocks is rapidly gaining ground. In this mysterious but acknowledged force, which produces a new crystalline arrangement, have we not all the required agencies to produce masses of any mineral which existed in the strata prior to the change? Is not something more necessary to account for these results, — some cause more universal than local chemical action?

In a practical point of view, this hasty grouping of our most prominent iron mines demonstrates a capacity of production in this country which has no parallel in other nations.

## 3. Considerations Relating to the Climate of the Glacial Epoch in North America. By Edward Hungerford, of Burlington, Vt.

The considerations here presented relate more particularly to the climatic influence of an extended accumulation of snow and ice in the higher latitudes, such as the glacial hypothesis supposes to have once existed.

1. Such a snow mantle, gradually extending itself into more southern latitudes from the north, presupposes the successive introduction of a diminished summer temperature into each such latitude.

2. A *depression* of the drift area would restrain the extremes of summer temperature, rendering the climate more insular, and might, under a rearrangement of the northern marine currents, diminish the mean temperature of that season of the year.*

3. But the fact that glacial markings are found at all elevations, in the low valleys as well as in the higher regions, renders it probable that, during the period of accumulation of the snowy mantle, the continent was at least as high as at present; for the ice-cap and its markings could not be formed over portions covered by the sea. The diminished summer temperature of that period, therefore, if not produced by a cosmical cause, was the result of an elevation of the northern latitudes, or of some portion of them. A depression of the summer temperature, from this cause, would not be accompanied by a fully corresponding depression of the winter temperature.†

4. A glance at the present arrangement of the lands in the north polar regions of the continent suggests that a moderate elevation of those lands, above their present level, would produce very great climatic changes by establishing continuity between the at present numerous detached, insular masses, thereby excluding the oceanic waters from northern bays and straits. Such changes might be sufficient greatly to extend the area of perennial snow in that section, and to initiate a

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*Iceland and the interior of Norway, between the 60° and 62° parallels have nearly the same mean annual temperature, but the summer temperature is lower in Iceland, and the snow line is much lower than in the interior of Norway.

†This follows from the considerations advanced in paragraphs ( ) and (2) under 6, which apply equally to the latitudes under consideration, in winter, at the present time, and under their present elevation.

process which should result in the glaciation of even the lower northern latitudes, without necessarily involving any very extended upheaval of the earth's crust in those lower latitudes. For, the process of snowy accumulation having been once begun in the extreme north, it is to be remembered that the direct climatic influence of every one hundred feet of such accumulation would be fully equal to the same amount of upheaval of the territory over which the accumulation takes place. The result will be to still further depress the summer and, to some extent, the winter temperature, and to provide for the further extension of the snow line southward. So long as the snow or ice-cap continues to be built up, so long the consequent climatic changes will extend southward, until some great reactionary cause is introduced. There would thus be developed the vast frozen mantle which the glacial hypothesis contemplates, — an elevated plateau of snow and ice extending over the present drift regions.

5. The frigorific effects of such a gradually extending accumulation of snow and ice, having a thickness of several thousand (from five thousand to possibly ten thousand) feet, may be noted as follows: —

(1.) The northward moving warm currents will be partially deflected by the icy barrier against which they impinge, thereby depriving the area to the northward of their influence.

(2.) The same warm currents will be partly elevated along the slope of the glacier front, and by the process of elevation their temperature will be depressed.

(3.) Consequent upon this loss of heat by elevation, as also upon that by contact with the glacier front, come loss of aqueous vapor and heavy precipitation along the outer margin of the ice cap. Such south winds, penetrating into the interior, will thus become comparatively dry, while the still colder and dryer north winds have free sweep over the plateau. Such dryness of the atmosphere facilitates radiation from the underlying surface, and becomes an important additional cause of cold.*

(4.) The direct radiation from the aqueous vapor of the atmosphere, the pouring of its own heat into space, is facilitated at such elevations by the absence of a superior stratum of vapor which would act as a screen, preventing radiation. At lower elevations such a screen of vapor still exists above the stratum of air next to the earth's surface.†

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* See Tyndall's experiments on absorption of heat by aqueous vapor. "Heat a Mode of Motion. Lecture XI."

† See the same work, pages 402 and following.

6. To these climatic effects more directly arising from the elevation of the plateau, we have still to add those which spring from the peculiar nature of a snowy surface, and which bear in the same direction towards the reduction of temperature.

(1.) The reflecting power of a snowy surface, by virtue of which it turns back the sun's rays into space, would deprive the earth of an immense amount of heat, which would otherwise go to temper the climate.

(2.) In a region free from snow, the heat which is not reflected is absorbed in vast quantities, to be again radiated from the earth, and to temper the climate. The bare earth serves as a great storehouse of heat. But owing to the low conducting power of snow, the larger portion of that heat which is not reflected from its surface is applied first to raise the temperature of the superficial snow only so far as to 32°, and then to convert it (if there be so much heat) into water which flows away, bearing its heat, thus obtained, into distant regions. Cold northerly winds blowing over such a snow-covered terrace, would, therefore, miss the moderating warmth that comes from a reservoir of heated land.

7. All the above considerations, it will be seen, point to the *prevalence of a severe* climate over the snow-covered country. To the usual effects of elevation, we have added, in this case, the peculiar effects flowing from the material comprising the plateau. Under the combined operation of these various causes, we may be justified in assuming that, at a distance not very remote from the southern margin of the ice-mantle, a climate of great severity would prevail throughout the entire year. This result accords also with the natural inference that the existence in the lower drift latitudes of a temperature sufficiently low to admit of prevailing perennial snow in them, as it involves the supposition of a severer cold for each successive latitude, in passing northward, must result, over a large portion of the territory back from the southern margin, in a rigorous winter temperature, even in our summer months, while the winters themselves would be periods of intense cold. Manifestly in the case before us the rapidity of diminution of temperature, or the difference of climate in passing northward, would be determined by the combined influence of difference of latitude, and of elevation of the snow plateau.

8. The confessed influence of temperature on the rate of glacier-motion gives importance to these considerations, on account of their

bearing on the motions of a continental glacier. The prevailing severe cold of the interior regions would be prejudicial to motion, and, without a favoring general slope of the country in one determinate direction, might even limit the motion to simple, irregular, local adjustments of equilibrium in the glacier mass.

On the southern margin, however, the two favorable conditions of glacial motion would always be realized. Here the climate would be comparatively mild, while the elevation of the glacier's front would itself be equivalent in effect to a sloping surface. The abundant snowy precipitation in the higher regions would supply the loss from melting in the lower.

9. Each successive belt of the present drift country would be twice subjected, for a long period, to the influences of glacial motion; once during the development of the snow mantle, southward, and once during its final retreat northward.

10. We are thus furnished with the means of accounting for all the erosive glacial phenomena, as well as for the transportation of the nearer drift and for the residual moraines, without resorting to a general, simultaneous, southward movement of the glacial mass throughout its entire length and breadth.

For the transportation of the remoter drift the agency of icebergs and ice-rafts would seem necessary.*

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* As this paper relates particularly to the climatic effects of the hypothetical snow-mantle itself, it was not thought necessary to introduce the very obvious consideration, that such an immense accumulation from atmospheric precipitation, as it demands, on the one hand, a good condenser, requires, on the other, a heated reservoir of water, from which the aqueous vapors may be derived, — a consideration which strongly militates against the extreme southern extension of the ice period, or of continental glaciers, by Mr. Agassiz. It is in those southern regions we must suppose such reservoirs to have lain.

## 4. RIPTON SEA BEACHES. By EDWARD HUNGERFORD, of Burlington. Vt.

(ABSTRACT.)

IN this paper the author gives detailed evidence of the aqueous origin of these deposits which occupy the sides of the pass through the Green Mountains, in Vermont, through which runs the road from Ripton to Hancock. The deposits are elevated 2,196 feet above the sea on the western slope of the mountains. Drawings of the terraces were exhibited, and a section showing three or four terrace levels, one above the other. The configuration of the country is unfavorable to the accumulation of any large body of fresh water in this vicinity.

The existence of such elevated terraces, in connection with other facts, leads the author to infer that, subsequent to the true glacial epoch, the country was submerged to, at least, the level of these terraces. His views upon this point were stated as follows: —

Accepting the possibility of such a climatic change as should result in the formation of an ice-cap over the northern portions of the continent, it is contended that the rigors of the fully-established winter, combined with the absence of any favoring slope, render the assumption of a general, simultaneous movement of the glacial mass in one direction a too doubtful one, that it should be relied on to account for the transportation of the boulder drift to distances of hundreds of miles from the parent rock.

On the other hand, the milder climate which would obtain on the southern, or seaward margin, of such a glacier, coupled with the slope of the front of the glacier, or with its unsupported face, would secure an abundantly free motion throughout a certain belt on the outer border. This moving belt would have its waste supplied by the heavy precipitations of snow upon the higher regions of the belt, which represent the *névé* regions of present glaciers.

During the advance southward, and during the final retreat northward of the great glacier, each successive belt of country would in turn be twice subjected to glacial erosion. The drift material would also, by this means, be transported to a limited distance, while for transportation of the remoter drift, as well as for the explanation of other phenomena, and especially the lower modified drift and the higher sea-beaches, a gradual submergence of the still ice-covered continent is necessary; and to such submergence the return of a milder climate may be ascribed.

In the progress of such a secular submergence, the sea would be brought in contact with successive portions of the great ice-belt, and icebergs of colossal extent would be set afloat all along the border of the glacier, which is constantly pushing itself forward into the ocean. Immense ice-fields, grinding upon the bed of the ocean, and on the coast, would still keep up the degradation of rocks, and of loose material, the finer portions of which would be partially distributed by currents. Such icebergs and ice-rafts would furnish the means of transportation to any distance.

As the ocean continued to encroach upon the land, the line of the ice-mass would become broken by deep indentations, which might account for (some) deflections in glacial striæ; the direction of flow, in such cases, being turned locally toward the nearest sea.

It is not necessary to follow out the details of this process. Long after the seas, in lower latitudes, had become partially freed from ice, the ice-barrier in the north would still send down its ice-fields and bergs, the later continuation of which process is still going forward upon our eastern coast.

Upon the re-emergence of the continent, the originally deposited drift would be, in part, remodelled by the waves. Smaller boulders would be rolled and the striations often removed, while partially or completely stratified deposits of finer material would be accumulated in favorable localities. The earlier periods of this emergence are marked by the elevated beaches. The later ones are represented by the Champlain clays and sands with their marine shells of recent species.

The events here enumerated succeed each other in the following order: —

1. The formation of a continental glacier, to whose partial and limited movements are due the erosive phenomena and the transportation of the drift over limited areas.

2. A depression of the continent, bringing the ocean in contact with the long glacial border, which, in its retreat, sends off icebergs and ice-rafts into the ocean. To these are attributed the further work of transportation of detritus and boulders.

3. Emergence of the continent, the higher beaches marking the earlier, and the Champlain terraces the lower stages of this process.

## 5. On the Lower Silurian Brown Hematite Beds of America.

By **Benjamin S. Lyman**, of Philadelphia, Penn.

In the south-eastern part of Smyth County, in South-western Virginia, within half a dozen miles south and east of the town of Marion, between that town and Iron Mountain, are thirty or more iron ore banks and natural exposures of lower silurian brown hematite, such as are found in such numbers along the Great Valley of Virginia and its continuation north-east to Canada and south-west to Alabama. A rough topographical survey of a part of this iron district near Marion shows, by means of two or three parallel sections from north-west to south-east across the general strike, that the rocks form two important saddles with a basin between, and that the ore exposures occur at corresponding distances on the opposite sides of the northern saddle and of the basin, as if they were the outcropping of four beds of ore regularly bedded with the other rocks; and at three (or four) of the ore banks the solid beds are to be seen. At the other exposures the ore has the same appearance as at almost all such exposures throughout the valley; namely, it is in solid lumps of irregular shape and of every weight up to three hundred tons or more, scattered irregularly through brown gravelly loam. The brown hematite is sometimes very pure, but often contains rounded or angular grains or pebbles of white quartz, and sometimes is merely a cement that binds together angular pieces of light brown sandstone. All these beds seem to lie within the Virginia and Pennsylvania Geological Formation No. I., wholly below the calciferous sand rock of No. II.

These brown hematite exposures of Smyth County resemble very closely in every respect a great number of similar ones of lower silurian age, from New Brunswick to Alabama, that are described either originally or at second-hand in Lesley's "Iron Manufacturer's Guide." Among these are a dozen or more that show the ore to be unmistakably in regular beds conformable to the other rocks. A few of the deposits seem (like Mr. David Graham's iron ore in Wythe County, Virginia) to come from the weathering of the upper part of a fissure vein of iron pyrites. The rest are more or less irregular deposits of loose lumps of ore of various size and shape scattered through brown loam, sometimes with white clay or sand, and the lumps are commonly less mixed with these other materials at a depth from the surface of the ground. There seems, indeed, to be nothing in these deposits to remove the impression made by the correspondence in position, by the solid bedding occasionally visible and by the other characteristics of the Smyth County exposures, that the iron ore was deposited in regular beds of greater or less extent and thickness at the same time as the other rocks, and that they have been broken into fragments at their outcrops, and that these fragments of hard and heavy ore have accumulated in quantities of various extent according to the lay of the ground, mixed with the loam that comes from the more thorough comminution or decomposition of the other softer rocks and of a portion of the ore itself. The lumps of ore are sometimes stalactitic in form and sometimes are hollow geodes; and these forms may have existed in the original beds, or they may perhaps have originated later in some cases. These deposits of loose lumps of brown hematite in loam seem, then, to be similar to accumulations of outcrop blocks of any bed of rock, such as sandstone, for example, or to the black dirt of a coal outcrop, except that the effect of the hardness and heaviness of the ore must be regarded. They are like the alluvial deposits of gold and tin ore, except that the lumps of iron ore are larger, owing to its coming from thick, solid beds, and it is lighter. As the lumps of ore in such deposits have been accumulating ever since the denudation of the rocks began, there might easily be found among the ore or near it, not merely the more or less decomposed outcrop rubbish of neighboring rock beds, but now and then comparatively recent vegetable deposits like the Brandon and Mont Alto lignites. At two or three points in Virginia and Pennsylvania, lumps of carbonate of iron have been found mixed with this brown hematite, and this would go to show that the ore was originally deposited as a carbonate like the coal measure beds of carbonate of iron, and has since been changed into brown hematite either in the solid bed or in the lumps scattered through the loam, a change that happens so often with the coal measure carbonates. The greater age of the lower silurian ores would not probably make the change more complete in their case, for they seem to have been thickly covered up until after the carboniferous epoch; but the position of the lumps of ore in loose loam would be especially favorable to the change.

This view of the origin of the deposits of loose lumps of brown hematite in loam may be of great practical importance, since it would help to show by the dip of the rocks and the lay of the ground something of the probable size of such a deposit, and in which direction a solid bed of ore might be looked for. The solid beds of ore may, however, be much less regular in thickness than the beds of iron ore of later age, and very likely resemble in this respect the early beds of magnetic iron ore.

The supposition some have entertained that these lumps of ore are derived from the percolation through the loam of water charged with iron dissolved out of rocks that contained iron in the form of iron pyrites or otherwise, and that the lumps are therefore concretionary in origin, and the result of a segregation so thorough that it sometimes leaves white clay or sand in contact with the ore, has more than one difficulty. The lumps are commonly not of the shape of concretions, for these must be more or less rounded or nodular, as they are formed about centres, and they could never be irregularly angular. The coal measure nodules of iron ore are placed also with a certain regularity in the slates where they occur; and not a trace of any such regularity is found in the lower silurian lump deposits. It seems hard, too, to conceive of so complete a segregation as would be necessary, in loose, gravelly loam; and it would be more natural to expect that iron-bearing waters, in soaking through such loam, would form an iron ore comparatively homogeneous, but mixed throughout, with the impurities of the loam. It would seem, rather, as if the effect of the percolation of the water in these deposits had been commonly to give a ferruginous covering and character (taken from the ore) to the materials of the loam when they came from rocks that did not have that character.

The strength of the argument furnished by these Smyth County ores depends in a measure upon the accuracy of the survey; but although this was but rough, the limits of error in each cross section are so small compared with the distances apart of the different beds that, in a similar case, the identity of coal beds exposed on opposite sides of a saddle or basin would be quite undoubted, and the uniformity in these distances over a space of several miles is even surprising. The correspondence of the beds in the different cross sections is, however, somewhat less certain in some parts. On one section the outcrops of the four beds are exposed on each side of the northern saddle, and probably the three upper ones are exposed on the north side of the southern saddle; then on a section about two miles to the east, the three lower beds seem to be exposed on the north side of the southern saddle; and on a section two miles and a half still further east the upper and lower beds seem to be exposed, also on the north side of the southern saddle. A little allowance must be made in two or three of these places for the slipping of the ore lumps down hill from the real outcrop of the solid ore bed. The exposures marked in these sections are almost all very near to the section lines, so that there can be no appreciable error from any possible slight mistake in the direction of the strike, in projecting the exposures upon the sections; and, with occasional small allowances for slipping of the ore lumps down hill, all the other exposures observed correspond well with the theoretical outcrops of the four beds.

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## 6. ON RECENT GEOLOGICAL DISCOVERIES IN THE ACADIAN PROVINCES OF BRITISH AMERICA. By J. W. DAWSON, of Montreal, Canada.

(ABSTRACT.)

THE object of the paper was to notice some recent discoveries which, though of interest, might have escaped the notice of members of the Association.

In New Brunswick, the older rocks in the vicinity of the city of St. John have been reduced to order, and their probable ages ascertained, principally through the labors of Mr. Matthew, Mr. Hartt, and Prof. Bailey. The first step toward the knowledge of their precise date was the discovery of a rich land Flora in some of the upper beds, next below the lower carboniferous rocks which overlie them unconformably. These fossil plants I was enabled to recognize as of the Devonian period, and the zealous researches, more especially of Mr. Hartt, have brought to light no less than forty to fifty species, or half of the whole number known in the Devonian, of Eastern America, as well as six species of insects, four of which have been described by Mr. Scudder.* These insects are the first ever found in rocks older than the carboniferous.

These rocks, consisting chiefly of hard shales and sandstones, having been ascertained to be Devonian, there still remained an immense thickness of underlying rocks of uncertain age. In the upper member of these rocks the same active observers already mentioned have discovered a rich primordial fauna, embracing species of *Conocephalites, Paradoxides, Microdiscus*, and *Agnostus*, as well as an *Orthis* and a new type of Cystidian. These fossils are regarded by Mr. Hartt and Mr. Billings, as of the age of Barrande's "Etage C," and as marking a new and older period of the "Silurian Primordial" than any other as yet recognized in America, with the exception of the slates holding *Paradoxides* in Massachusetts, and the similar slates of the "Older Slate Formation" of Jukes in Newfoundland. Descriptions of these fossils, by Mr. Hartt, will be published in the edition of Acadian geology now in press. It is proposed to call this series, represented in New Brunswick by the St. John slates, the *Acadian Series*.

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* Canadian Naturalist and Geologist, 1867.

Below these primordial beds are highly metamorphosed rocks, at least nine thousand feet in thickness, which have not afforded fossils. A portion of these beds, consisting principally of conglomerate and trappose beds, is regarded by Messrs. Matthew and Bailey as of the age of the Huronian. The remainder, containing much gneiss and a bed of crystalline limestone, they regard as Laurentian. If this view is correct, and it certainly seems to be probable, these rocks, thus rising through the oldest members of the lower silurian, and forming a stepping-stone between the Laurentian of Newfoundland and that of New Jersey, show that the foundations of the north-east and south-west line of the east side of North America were already laid in the Laurentian period. Still, it is not here, but farther west, that we are to look for the dividing line between the great inland silurian basin of America and that of the Atlantic coast, the latter, as has been pointed out by Prof. Hall and Sir W. E. Logan, so remarkably distinguished by the predominance of mechanical sediments, and by a development of the lower, rather than the upper members of the lower silurian.

To ascend from these rocks to the carboniferous: recent labors of Mr. Davidson, Mr. Hartt, and the author had led to the division of the lower carboniferous into successive subordinate stages, and to the determination of most of the marine fossils, and also to the explanation of the curious and apparently anomalous fact that some forms allied to Permian species actually exist in the lower carboniferous, under the productive coal measures. These researches had also shown that no distinction into sub-carboniferous and carboniferous proper can fairly be made in Nova Scotia, notwithstanding the grand development of the carboniferous in thickness. After noticing the large advances made in the fossil botany of Nova Scotia and New Brunswick, the paper referred to the discovery by Mr. Barnes of two new species of insects, and to the discovery by the writer of a new pulmonate mollusk described by Dr. P. P. Carpenter as *Conulus Priscus.* There are thus in the coal formation of Nova Scotia a *Pupa* and a *Conulus,* or *Zonites,* generically allied to living pulmonates, and representing already two of the principal types of these creatures.*

Specimens of these fossils were exhibited, and also specimens and a photograph of the Laurentian fossil *Eozoön Canadense,* more particularly mentioning the specimen recently found by the Canadian survey at Tudor, which shows this organism in a state of preservation comparable with that of ordinary silurian fossils.

## 7. THE WINOOSKI MARBLE OF COLCHESTER, VT. By C. H. HITCHCOCK, of New York, N. Y.

(ABSTRACT.)

THE Winooski Marble Company hold a property of five hundred and ninety-six acres five miles distant from Burlington, upon which are exposures of a variegated marble well situated for working. The rock is a dolomite, containing twenty per cent. of silica, alumina, and iron. Some of the varieties exhibit nodules of calcite enclosing quartz, evidently formed like concretions. When present these small nodules render the stone harder to saw than the common marbles, rendering its cost about one third greater. The colors are various shades of red, chocolate, and brown, with patches, and irregular lines of white. These colors adapt the marbles to match with the modern style of furnishing houses better than the white and clouded varieties. Stones somewhat like this are common in Europe, but, being of jasper or porphyry, are very much more difficult to work. Slabs twelve feet long can be obtained of the Winooski marble, and of three feet or more in thickness. No work is now being done upon the property. The rock is of the same age with the red sandrock of Burlington, or the Lower Potsdam, at the base of the Lower Silurian. The slaty layers above are characterized by the presence of *Olenellus Thompsoni* and *O. Vermontana.*

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* Acadian Geology. Second edition.

## 8. THE GEOLOGY OF VERMONT. By C. H. HITCHCOCK, of New York, N. Y.

(ABSTRACT.)

THE Final Report upon the Geology of Vermont, published by the authority of the Legislature in 1861, contains all that was known of the rocks of the State down to that period. Since then the age of many of the groups has been determined more satisfactorily. The grouping of the formations upon my geological map in the Report, as "Upper Silurian" and "Mostly Devonian" were typographical errors. We should now employ the following schedule of rock formations in the State. These were exhibited upon a colored map of the size of the large map of Mr. Walling.

### UNSTRATIFIED ROCKS.

Granite, syenite, protogine, with the traps and porphyries.

### EOZOIC SYSTEM.

Laurentian gneiss of West Haven and the Green Mountain gneiss.

### PALEOZOIC SYSTEM.

#### *Lower Silurian.*

1. Potsdam group — including the red sandrock, part of the "Hudson River" slates, part of the Georgia slate, most of the quartz rock, and the Potsdam sandstone of West Haven.
2. Calciferous sandrock.
3. Levis group, including the "Eolian limestones," "Hudson River" limestones, and the greater portion of the Georgia slate.
4. Lauzon group, including most of the "Talcose conglomerate," "Talcoid schists," and part of the Talcose schist.
5. Sillery group, the upper part of the Talcose schist. The Mica schist is 3, 4, or 5.
6. Chazy, Birdseye, and Black River limestones.
7. Trenton limestone.
8. Utica slate.

#### *Upper Silurian.*

1. Calciferous mica schist.
2. Clay slates of EastVermont (?)

### *Devonian.*

Upper Helderberg limestone (?)

### *Cænozoic.*

Miocene, tertiary, and alluvium.

The Green Mountain gneiss enters the State from Massachusetts on the south and passes into Canada, following the course of the Green Mountains. Its gneissic character is often very obscure. Our sections give the formation an anticlinal structure, sometimes an overturn. In calling it Eozoic, we do not necessarily regard it as older than the Cambrian or Huronian. The following considerations render its Eozoic age probable.

1. The rock is on the line of the continuation of the Laurentian of New Jersey and Eastern New York, as confirmed by the recent observations of Sir W. E. Logan and Prof. James Hall. Between its known occurrence, in New Jersey, intervenes only the Hoosic Mountain range in Massachusetts and Connecticut. At one place the continuity of outcrop is interrupted by overlying limestones of the Levis group.

2. It exhibits generally an anticlinal structure. In Massachusetts, this may be observed at the Hoosic Tunnel. In Vermont upon sections Nos. 2, 4, 5, 9, 10, 10*a*, 11, and 13. In all the others the strata dip uniformly in one direction, and part of the formation must be inverted. According to the Canadian reports, in three sections across the continuation of the Green Mountains, "the strata have been observed to maintain dips generally at high angles in opposite directions from the axis of the mountain, with much constancy, for upwards of twenty-five miles."

The anticlinal structure is further proved by the repetition of the supposed Potsdam and Levis rocks upon both sides of the central gneiss, at Wallingford and Plymouth.

3. The Potsdam rocks flank the gneiss upon the west side as far north as Middlebury. If the gneiss were the sillery sandstone, as has been claimed, this quartz rock ought to belong to the Lauzon group.

But upon following the quartz rock northerly it is seen to terminate at Starksboro, near which termination it presents many of the characters of the red sandrock or Lower Potsdam, extending to Starksboro from Highgate. The quartz rock is probably the same with the red sandstone, as both are overlaid by the Levis limestone and resemble each other much, near their supposed union. I find this view of the identity of those two formations confirmed by the late map of the Canadian survey, published in 1866.

4. A conglomerate at the base of the Potsdam (quartz rock) contains pebbles derived from the gneissic rocks. At the western border of the gneiss there appears in Stamford, Sunderland, and Ripton a peculiar granite whose constituent quartz is blue, and I have seen nowhere else a granite of this character. The conglomerate with pebbles of blue quartz has been observed at Sunderland, E. Wallingford, Pittsford, and in boulders about Rutland. The Wallingford rock contains also pebbles of gneiss. These examples appear to prove that the granite existed before the deposition of the Potsdam, and if older, it is probably Eozoic. A conglomerate perhaps of the Lauzon group, in Lincoln, also contains pebbles of blue quartz.

By recent observations the members of the so-called Taconic system appear to be of lower silurian age. By following their distribution northerly, the probable equivalency of the various members may be made out. The typical localities for this system were largely in the south part of the State. The "Granular Quartz," by our observations, appears to belong to the Potsdam group; the "Stockbridge limestones" (Eolian) belong to the Levis or Philipsburg limestones; the "magnesian slate," to the Lauzon group; the "Taconic" and "Roofing slate," in part to the Levis and in part to the Potsdam series. The "Black slate" seems to have been properly located beneath the ordinary Potsdam sandstone. Thus as the system is chiefly Lower Silurian in character, it does not seem best to retain the name of Taconic for that portion which alone belongs to the position assigned by Prof. Emmons. The reference of trilobites like *Olenus* and *Paradoxides* to a system of rocks older than those containing *Asaphus* and *Trinucleus* was first made by Emmons. Hence although he insists that the red sandrock of Vermont is newer than Taconic, if the name be retained, it should be applied to the formations called locally the St. Johns groups of Newfoundland and New Brunswick, the Braintree slates of Massachusetts, and the Lower Potsdam of Vermont. In no case, however, can a Taconic group be legitimately correlated with the Huronian of America or the Cambrian of Europe. It should, on paleontological grounds, be regarded as a subordinate part of the Lower Silurian system. The few simple fossils of the Cambrian ally it with the Laurentian under the general designation of Eozoic.

## 9. EXPLANATION OF A GEOLOGICAL MAP OF MAINE. By C. H. HITCHCOCK, of New York, N. Y.

(ABSTRACT.)

THE results obtained during the progress of the Maine Scientific Survey in 1861, 1862, have been embodied in a large map, the property of the Legislature. By the permission of the executive officers of that State, the map was exhibited to the Association. Gneissic rocks with granite and patches of schist and limestones, occupy the hilly parts of York, Cumberland, and Oxford Counties. This is the remotest extension of the White Mountain series. The same appear in great amount along the coast, including the area twenty miles back, between Portland and the Penobscot River. Between those gneissic masses commences a mica schist, extending north-easterly into New Brunswick. Where it crosses the Penobscot River, it occupies the area between Medway and Bucksport. At the eastern State line it is narrower, including Orient, Amity, and part of Hodgdon. In Hancock County, a range of granite commences at Mount Desert Island and extends north-easterly, entering New Brunswick with the entire width of the Eastern Schoodic Lakes. Another development of mica schist appears on the south of the granite, followed in the south-east part of Washington County by smaller deposits of flinty slates, the Lower Helderberg, Upper Devonian, and by great masses of trappean rocks.

The northern part of the State is sparsely settled, and it is not everywhere easy to trace out the strata. But it is in this section that the greatest number of fossils are found. A wide formation of clay slate succeeds to the great central belt of mica schist. One like it reappears on the Lower Alleguash waters and the St. John River above the Great Falls. This is also underlaid by the Quebec group along the Canadian border. The northern part of the State, from the distribution of these two groups, would appear to form a great synclinal basin, holding at various parts of its surface a long area of Oriskany sandstone, Cauda-Galli grit, and various fossiliferous Upper Silurian and Devonian strata. The clay slates about Waterville contain fine examples of *Nereites* and *Myrianites*. The Port Daniel limestone of Lake Sedgwick has afforded a fine series of trilobites and brachiopods. The surface geology of Maine is remarkably interesting. Examples of local glaciers, and thirty-four "eskers," or "horsebacks," have been described. The chief exports of mineral wealth are granite and lime.

## 10. THE DISTORTION AND METAMORPHOSIS OF PEBBLES IN CONGLOMERATES. By C. H. HITCHCOCK, of New York, N. Y.

(ABSTRACT.)

AT the Newport meeting of this Association I presented many facts relating to the distortion of pebbles in the conglomerate near that city, under the title, "Geology of the Island of Aquidneck." Since that time my father has described other localities, in his Final Report upon the Geology of Vermont, where he takes the ground that conglomerates may become altered into schists so completely that the original structure will be obliterated. I have treated of the same subject fully in my Preliminary Report upon the Geology of Maine, 1861, and in my two reports upon the geology of that State have described four new localities, one of which, in Sandy River Plantation, exhibits the phenomenon of distortion in great perfection. All these matters were fully treated in the paper read before the Association, but I will present for publication only some facts on this subject obtained from European authorities.

There are other phenomena analogous to the distortion of pebbles. First, I refer to the distortion of fossils. No better illustration can be given than the grotesque and varied forms of the trilobite, *Angelina Sedgwicki*. Some have lain across, some along, and some oblique to the clearage of the slate, and a compressing force has distorted them, so that it is rare to find one showing the normal shape.

Secondly, the microscopic examination of slates has shown an elongation and flattening of particles within them. Tyndall refers to two examples, the German razor stone and the greenish spots in writing slates.

In the Royal Museum of Economic Geology at Jermyn Street, London, are two examples of the distortion of pebbles by pressure. The first is a collection made by Mr. Salter of quartz stones, "which have been subjected to enormous pressure in the neighborhood of a fault. These rigid pebbles have, in some cases, been squeezed against each other so as produce mutual flattening and indentation. Some of them have yielded along planes passing through them, as if one-half had slidden over the other; but the reattachment is very strong. Some of the larger stones, moreover, which have endured pressure at a particular point are fissured radially around this point." The other example is of stones in a Permian conglomerate, and the following is Prof. Ramsay's description of them. The "component stones are often from three to nine inches in diameter, and where they touch in the rock they are not scratched, but indent each other at the points of contact; the indentations being due to the fact that, while those gravels were still incoherent, over great areas, the upper parts of the New Red Series, the Lias, and perhaps other newer strata, were piled upon them, and the vertical pressure consequent on this vast superincumbent pile induced a lateral pressure in the loose-lying pebbles of the conglomerate; so that being squeezed, not only downwards, but outwards, they ground on each other, and, perhaps partly by the aid of intervening grains of sand, circular indentations were formed sometimes an inch in diameter. Some of them are fractured and re-cemented. The fractures were produced by pressure, generally close to faults."

Very recently H. C. Sorby, Esq., F. R. S., of Sheffield, England, has made an important suggestion upon the mutual interpenetration of pebbles of limestone in the conglomerate of the Nagelflue in Switzerland, which enables him to account for the phenomena without invoking the aid of plasticity. The case seems to be one where there is simply an indentation, without elongation or flattening. We doubt whether the phenomena observed in America can be explained without plasticity, but desire to adopt the principle, and explain all the appearances by it, if possible.

Mr. Sorby writes, "All previous writers had attempted to explain the impressions in the pebbles either by mere mechanical or simple chemical action, localized by mechanical conditions. The facts point so strongly to both agencies, that it is easy to understand why the opinions ever varied between the two extremes; and it now appears to me astonishing that no one was led at an earlier period to suggest a correlated action of both. At the same time we must admit that a large part of those who have studied the question did so before the doctrines of the correlation and conservation of force were generally admitted or understood. It is mainly as an illustration of the applicability of such principles to geology that I have been led to draw attention to the impressed pebbles.

"In the case of the majority of substances mechanical pressure increases their solubility. For example, if a crystal of common salt is placed in a perfectly concentrated solution, so that no more would be dissolved under the ordinary pressure, on applying to the solution a pressure of, for example, a thousand pounds to the square inch, and maintaining it for a sufficiently long time, more salt is dissolved, and is again deposited on removing the pressure. I also found that a glass rod with a small, round termination, pressed with a force of ten pounds against a plate of rock salt, had, in the course of a year, produced a well-marked depression, surrounded by a ring of small crystals raised above the level of the original surface. The salt had been exposed to the atmosphere, in which case a thin film of moisture is generally present on the surface; and, since the force of capillary attraction varies inversely as the width between two plates, where the salt was in almost absolute contact with the glass, the force with which the liquid would penetrate between them would be very great. It therefore appears to me nearly certain that the pressure would be, to a considerable extent, sustained by a thin film of liquid, which, being thus under pressure, would dissolve more salt than the rest of the solution, and, by slow diffusion amongst it, the salt would thus be transferred from where the pressure is greatest to where it is less.

"Now these experimental results entirely satisfy the conditions met with in the case of the impressed limestone pebbles. Pressed one against the other with great force, at a considerable depth below the surface of the earth, and surrounded with water saturated with carbonate of lime, in accordance with the principles I have described, the limestone would dissolve, so that in time one pebble would penetrate into the other, and carbonate of lime would be deposited in a crystalline form elsewhere, where the pressure was less. This explanation agrees admirably with the various facts. The structure of the limestone proves most conclusively that the depressions were produced by actual removal of material, and not by its yielding as a plastic substance. Moreover, it is only the carbonate of line which has been removed, — only the soluble part of the pebble, — the insoluble earthy portion having been left behind at the bottom of the depressions; and therefore the removal cannot have been effected by mere mechanical means, which would have removed the whole indiscriminately. I attribute the solution of the material of one of the pebbles, and the unaltered outline of the other, to a difference in their hardness, or the amount of earthy or sandy impurities; whilst, at the same time, I think it probable that a difference in curvature may have considerable influence."

There has been a large number of communications upon the indentation and alteration of pebbles in Europe. The earliest were noticed in the Jahrbuch für Mineralogie for 1836 and 1843 by Lortel; in 1840 by Blum; in 1841 and 1848 by Escher von der Linth, etc.

The first notice of them in this country was in my father's Report upon the Geology of Massachusetts in 1833. Hence we may claim for an American writer the credit of having first brought the attention of the scientific world to this subject.

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## 11. TRACTS OF ANCIENT GLACIERS IN THE WHITE MOUNTAINS OF NEW HAMPSHIRE, WITH A FEW REMARKS UPON THE GEOLOGICAL STRUCTURE OF SOME PORTIONS OF THAT GROUP.

By GEORGE L. VOSE, of Paris Hill, Maine.

IT was stated in this paper, that while the general direction of glacial action in the western part of Maine is from north and north-west to south and south-east, the furrows upon the rocks, in that part of the Andrôscoggin valley, extending from Gorham, in New Hampshire, to Bethel, in Maine, and which has a course from west to east, varied from S. 20° E., to S. 80° E.; and that, while the furrows in the depressions between the higher summits of the main chain of the White Mountains point to the north and north-west, those in the Peabody valley range from N. 30° E. to N. 40° E., thus according with the general direction of that valley, and being nearly at right angles with the furrows in the valley of the Androscoggin. It was thus inferred that in addition to the general movement of ice over this district, from north and north-west to south and south-east, there have been local glaciers which were confined to the valleys of the Peabody and Androscoggin Rivers.

It was farther stated that the whole surface geology of the district upon the west of the White Mountains, from Fabyan's to the Notch, furnished, in various forms of modified drift, plain evidence of the action of large bodies of water at a very recent period; but that whether this locality, now two thousand feet above the sea, had been covered by the ocean, or by bodies of fresh water, retained by some barriers not now existing, was not determined.

Regarding the arrangement of the great central mass of rocks forming the main chain of the White Mountains, it was stated that this portion of the group appeared to have neither the anticlinal build of the older geologists, nor yet the regular synclinal build more recently suggested; but that the top of Mount Adams, of Mount Jefferson, of Mount Clay, and the section from Tuckerman's Ravine through the Lake of the Clouds, all seemed to show a prevalent steep dip to the north and north-west; and it was suggested that the main chain of the White Mountains was formed by a fragment of the western slope of an immense anticlinal wave, of which the crest would have been over the Peabody valley, and of which perhaps a fragment of the eastern slope may be found in the opposite and parallel range of the Carter Mountains; in which case the Peabody valley would be a valley of denudation.

The feature so common in the relief of these mountains, the long, gentle, northern slope, and the abrupt southern descent, was considered to be due more to the position and direction of the bedding of the rocks than to the movement of ice from north to south over these summits; although it was believed that the latter operation played an important part in the rounding off of these mountains.

## 12. THE RED SANDSTONE OF VERMONT AND ITS RELATIONS. By JOHN P. PERRY, of Cambridge, Mass.

THE representations made of the red sandstone of Vermont, at different times and in various places, have been exceedingly discordant. Indeed, in not a few cases, the views entertained and exhibited, respecting this formation, have been diametrically opposed.

Presuming that the rocky beds themselves have a story to tell, it may be desirable for us to put them on the stand, and apply to them the most crucial tests in our power.

As the Association for the Advancement of Science is now convened in the vicinity of these rocks, it will be easy, for such of its members as desire, to subject, if they have not already done so, and if they have, to re-subject, this fragment of the Old Book of Nature to a personal examination. As a help in this direction, let us raise a few queries in regard to the formation, and endeavor to answer them by an appeal to facts.

I. And, in the first place, we may ask, What is the Red Sandstone of Vermont?

With the exception of the late Dr. Emmons, who long ago described this rock as Potsdam sandstone, it has been, up to a very recent day, quite generally regarded as belonging to the Medina formation of the New York geologists.

The rock itself is a narrow band of sandstone, usually red, sometimes gray, and often calcareous, lying in the lower portion of the Champlain slope of Vermont, and dipping gently to the east. It has been much eroded, what remains seeming to be only a small part of the original formation.

As early as 1847, Prof. Thompson discovered fragments of trilobites in a portion of the band situated in Highgate. These failed, however, to attract much attention; and thus the real age of the rock remained, if not undetermined, at least, for the most part, unrecognized.

The remains of two or three species of fossils were collected by Dr. G. M. Hall and myself at this locality, at various times between 1855 and '60. On my showing several glabellæ of these fossil trilobites to E. Billings, Esq., early in the summer of 1861, he at once remarked, "They are *Conocephalites*, and the rock must be Potsdam sandstone."

Without stopping to mention the different individuals * who have engaged with praiseworthy zeal in the study of this formation, I may simply add that, since 1861, the rock has come to be very generally, if not universally, recognized as belonging to the horizon of the Potsdam sandstone.

II. We may next ask whether this sandstone be succeeded on the east by newer formations, that have been disguised by metamorphic action?

It was for a long time, and I suppose is still asserted, that this rock underlies more recent formations on the east, probably of Silurian and Devonian age; and that the latter, having been subjected to intense heat, have been so transformed as to be scarcely recognized in their new character; in short, that all the so-called Taconic rocks, as described by Dr. Emmons, are later than the red sandstone.

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* It would give me great pleasure to refer in particular to the late Dr. Emmons, to the late Profs. Adams and Thompson, to the late President Hitchcock and his associates in the Geological Survey of Vermont, to Sir William Logan and E. Billings, Esq., of the Canada Survey, and last, but by no means least, to Prof. Marcou, as gentlemen by whose labors I have been not a little assisted, in various ways, in my study of the rocks of Western Vermont.

Without dwelling on the fact that these more easterly rocks do not ordinarily exhibit such marks of metamorphism as the theory implies, and that careful search has shown that some of the Taconic rocks are not a little fossiliferous, I would insist, in the first place, that the Red Sandstone does not pass under as the dip might seem to suggest, but simply rests against the so-called newer formations on the east. This may be seen in Swanton, where the Potsdam band has been cut through, the excavated valleys thus affording exposures of the underlying rocks as they occasionally crop out, as well as of the overlying sandstone.

But more than this; the red sandstone, in several instances, extends over almost the entire, if not over the whole, width of the Taconic series. This superposition is well exhibited in the counties of Addison and Chittenden, where the Potsdam formation stretches from Charlotte and Ferrisburg eastward to Starksboro, overlying nearly, if not quite, all the Taconic rocks, which occasionally crop out, and may be readily recognized by a practised eye. Something very similar is observable in Franklin County; also, as I think, in the extension of the same range into Canada.

Some, however, may be disposed to urge that there has been an overturn, and that thus the Potsdam formation, though really older than the Taconic strata, usually lies above them. If reference be made to partial or local inversions, it may be said that nothing of this kind, so far as I can judge, is adequate to account for the position of the rocks at the localities already cited; indeed, the two series of beds sustain substantially the same relations to each other through the entire length of the State. If, on the other hand, appeal be made to a general overturn, it is right to demand the proof. This I have never been able to get. In fact, of such an overturn I have been unable, after years of search, to discover the slightest evidence, or the faintest trace. On the north-west side of Snake Mountain, in Addison, the base of the sandstone is found so resting on the underlying slate as to show that the present is substantially its original position. Similar evidence reveals itself at Lone Rock Point, in Burlington, at Mallet's Bay, in Colchester, and at other localities. And then it may be added, that the beds would have been more broken in case of an inversion, and that layers of rock containing rain-drop impressions are found in their normal position.

The theory of metamorphism, therefore, so far as invoked in the present case, seems to fall to the ground, while facts generally, so far as I have been able to find them having a bearing on the subject, decidedly testify that the red sandstone does not extend under metamorphic formations on the east.

III. Again, let us inquire whether the sedimentary beds which underlie the red sandstone be an extension of the Potsdam formation downward?

The gray siliceous rocks at Potsdam, N. Y., have been, for the most part, regarded as the lowest portion of the sedimentary strata. When, therefore, it became certain that the red sandstone of Vermont must be referred to the same horizon, it was soon assumed that the underlying, fossil-bearing slates must be considered as a downward extension of the Potsdam sandstone. Whether this assumption be correct or not is to be determined by the import of the latter term. The word "Potsdam," in its earliest geologic sense, refers to the just mentioned sedimentary rocks in the township of that name. It also applies, by legitimate extension, to all rocky beds elsewhere found of the same specific life-period. Accordingly, to belong to this series of deposits, a formation must either exactly answer in age to the beds of sandstone at Potsdam, or else be a conformable extension, upward or downward, of rocks identical with them in the time of their deposition.

How is it now with the sedimentary strata before us? In the first place, the slates underlying the red sandstone of Vermont do not conform with it in dip. The variation referred to may be seen at Snake Mountain, in Addison County; in Charlotte, Shelburn, Burlington, and Colchester, in Chittendon County; also in St. Albans, Swanton, and Highgate, in Franklin County, as well as in other places.

Again, there is a lack of conformity in the strike of the sandstone, and that of the underlying slates. This fact may be observed at the several localities just mentioned, as well as by a glance at the representation given on the Geological Map, published in the "Final Report," on the Geology of the State.

Once again, it should be remarked that there is a lack of conformity in the organic remains. Without enumerating the several fossils, I would simply remark that all the vegetable and animal remains, thus far brought to light in these respective groups of Vermont strata, are specifically distinct. Indeed, no species is yet known to have been discovered, either in this State or elsewhere, common to the two systems of rocks, and therefore nothing to indicate that they are of the same life-period.

It should accordingly seem, from this threefold lack of conformity, that the beds underlying the red sandstone are distinct from it, and cannot be, with any propriety, either referred to the formation, or regarded as belonging to the period called Potsdam.

IV. What relation, then, we may now ask, does the red sandstone sustain to the underlying formations?

The true answer to this query must depend upon the determination of the age of the inferior rocks. These were long and generally, though by no means universally, regarded as Utica slate and Lorrain shale. They should be divided, as is most probable, into two parts, and may be locally designated as Black, or Swanton slate, and Brown or Georgia slate. That they are not of so late an age as the Utica and Lorrain beds is apparent from what has been said of the red sandstone which overlies them. In some cases, also, the Swanton slates may be seen beneath the Potsdam formation, not only along its western, but also near its eastern limits. So the Georgia slate may be shown in some places, as in Swanton, to underlie the Potsdam sandstone in its extreme extension eastward. These facts, it is thought, entirely meet the supposition sometimes made, that the underlying slate is Utica, the Potsdam beds having been pushed westward, and thus made to overlap it; for there is abundant evidence that the so-called lateral movement was, at the best, very slight.

While, then, the underlying beds cannot be regarded as Utica slate, or Lorrain shale, while they are also older than the Potsdam formation, we may well ask what their organic remains teach us. It is this: that these slates clearly answer to the Primordial Zone of Barrande. The fossils are plainly primordial in type.

And what do the fossils of the red sandstone teach us? They likewise unmistakably belong to the Primordial Zone of Life, and thus show that the sandstone is primordial. But they not only form a part of the first grand type of life, they are also specifically distinct from those of the underlying slates, and a trifle later in the geologic sense of the term. In this wise they indicate the relative age of the Potsdam sandstone.

This being the state of the case, it must be clear that, while the underlying and the overlying beds are discordant in dip, in strike and included fossil remains, they are yet nearly related; that they both should be regarded as belonging to one and the same great zone of living existence; that the red sandstone accordingly claims recognition, and must, of good right, be recognized as an upper division of the Tatonic or Primordial System of rocks: nay, more, that it follows the inferior groups, after a short break in time and a slight interruption in the organic succession, and seems to cap them with the more mature forms of the same grand type of life.

V. We may, accordingly ask, as a final question, whether the red sandstone properly belong to the Lower Silurian System of rocks?

The Potsdam formation has been almost universally counted as the base of the Champlain, or Lower Silurian beds of New York. And this determination of the mass was very natural, especially at the time and place at which it was originally made; for no fossil-bearing strata were then known to be older; while at the typical locality the formation in question rests directly upon rocks usually called igneous, and is, in many localities, succeeded by the calciferous sandrock.

It seems to be a fact, however, that the Potsdam sandstone and the calciferous sandrock are stratigraphically unconformable. This discordance may be seen at Chazy, N. Y., while the relations generally of the two formations may be well observed at Whitehall, N. Y., and West Haven, Vt.

These groups of rocks, moreover, are seen to be unconformable when looked at palæontologically. Indeed, there is an almost total break in the sequence of life between the two formations. Still this point alone is not enough; it is only negative. It will have greatly increased force, if it can be connected with positive testimony.

And there is additional evidence of a positive kind. A different and an advanced zone of life seems to commence with this higher formation. The characteristic primordial forms disappear almost entirely with the Potsdam, while a new and what should be perhaps called the second great chronological type of existence makes its appearance in the calciferous. Thus looked at under the relations of time, there is seen to be a marked difference in the two formations. The types of life are clearly distinct.

These facts, accordingly, seem to indicate that the Potsdam sandstone is not correctly described, and cannot be properly viewed as the lowest member of the second great group of fossiliferous strata; that of good right it should be regarded as the summit, or crowning portion of the Primordial Zone of Life; and that thus the calciferous formation both presents itself in nature, and in consequence claims recognition as the true base of the Champlain, or Lower Silurian System of rocks.

Having thus cursorily surveyed the red sandstone of Vermont, as it is in itself, and in its more general relations, I will close this paper with a brief synopsis of the two great systems of rocks, which have been under review. Reading from below upward, we have

II. Champlain
- 3. Upper: — Birdseye, Black River, Trenton, Utica, and Lorrain.
- 2. Middle: — Chazy, in its several divisions.
- 1. Lower: — Calciferous, in its several divisions.

I. Taconic
- 3. Upper: — Potsdam, in its several divisions.
- 2. Middle: — Black and Brown Slates with Limestones and Sandstones.
- 1. Lower: — Talcose and talcoid Slates with Limestones and Quartzites (or Conglomerates.)

The above is given as the most satisfactory general view that I have been able, up to this time, to get of these rocks, after a long study of them in the field. And it is presented, not as an ultimatum, but simply as an essay toward the solution of some of the manifold difficulties involved in one of the most intricate and perplexing sections of the Geologic Record; presented with diffidence, and still with unwavering confidence in the truth of nature; presented in the hope that new light may be elicited, that old errors, so far as they exist, may be discarded, and that thus a more consistent understanding of these formations may be at last secured.

In this summary, the terms "Taconie" and "Champlain" are used, not as implying any theory, but because they are familiar and local. Insomuch as they were introduced long ago, are simple, short, and convenient, as well as locally descriptive, — also, as commemorative of the honored dead, — I see many good reasons for retaining, and no occasion for discarding them.

## 13. ON THE ORIGIN OF THE SO-CALLED LIGNILITES OR EPSOMITES.

By O. C. MARSH, of New Haven, Conn.

(ABSTRACT.)

THE peculiar jointed or columnar structure, which in various formations often unites the adjoining surfaces of two layers of limestone, has long been a puzzle to geologists, and many attempts have been made to solve the mystery of its origin. Indications of this structure may be detected in nearly all limestones, but only under peculiar circumstances is it developed in its full perfection. Probably the finest illustrations of it in Europe are to be seen in the Muschelkalk of Germany, where it appears to have first attracted attention. In this country, the Clinton limestone, of Niagara County, N. Y., affords, perhaps, the most perfect specimens, as well as the best field for investigating the subject.

An examination of this structure, as it usually occurs *in situ*, shows a series of columnar markings and separate columns passing off at right angles from a seam between two beds of limestone or calcareous shale. The individual columns vary from one half to four inches in length, and one fourth to two inches in diameter, although they are sometimes much larger. In nearly all instances they pass from the lower layer into the one above, but rarely the reverse takes place. The sides of the columns are always marked with longitudinal groovings or striæ, and their free ends are usually covered with a rounded or pointed cap of clay. In the older rocks this clay covering has become hard, and is firmly attached to the column. At some localities the more perfect columns have a fossil shell or other organic substance on their summit beneath the clay. The columns themselves are of precisely the same material as the surrounding rock, although not unfrequently they are coated externally with some foreign substance. Occasionally the structure takes the form of irregular jointed seams, reminding one of the sutures of the human cranium. At a few localities suture joints have been observed cutting the planes of stratification more or less obliquely, or even at right angles.

The limits of the present paper forbid more than a brief mention of the more important theories that have been proposed to account for the origin of this peculiar structure. In this country it appears to

have been first described by Eaton, in 1824, who considered the columns fossil corals, and applied to them the name of *lignilites*.* In 1831, Bonnycastle described a number of specimens, and was inclined to regard them, not as fossils, but as a new mineral due to infiltration.† A few years later Vanuxem claimed to have solved the mystery. The columns, he thought, were due to the crystallization of sulphate of magnesia, and he therefore gave them the name of *Epsomites*, by which they have since been most generally known in this country.‡ Prof. Hall, in his final Report, accepted this explanation, but suggested that the columns might, in some cases, be due to the crystallization of carbonate of lime.§ Prof. Emmons, also, in his Report, expressed the opinion that in one instance sulphate of strontia might have been the crystallizing agent.‖ Finally, in the General Report on the Geology of Canada, the nature and occurrence of this structure is discussed at some length by Dr. Hunt. The name *Crystallites* is used for the columns, and the suggestion is made that the "crystals may have been sulphate of soda, rather than a magnesia salt."¶ Views similar to those specified have been expressed also in several other works of acknowledged authority. That crystallization in some form was the cause of the structure seems to have been very generally accepted in this country up to the present time.

In Europe, especially on the continent, this question has attracted much more attention, and many and various attempts have been made to find a satisfactory solution of the difficulty. Early in the present century geologists there were already familiar with the structure. The first author, however, who made a special study of it was, was Klöden, of Berlin, who in 1828 gave a description of the forms that he had observed in the Muschelkalk at Rüdersdorf. He regarded the columns as fossils; and, although in doubt as to the nature of the supposed animal, proposed for it the name *Stylolites Sulcatus*.** A few years later he discussed the subject much more fully, and gave excellent figures of the principal forms he had met with.[*] The name *Stylolites*[†] has since been generally used in Germany for these forms, and no other appears to have been employed in other parts of Europe. As it has priority, and involves no theory, it should be universally adopted. The next careful investigation of the structure was by Quenstedt, who in 1837 published an important paper on the subject.[‡] Having observed that some of the more perfect columns were capped with fossil shells, he came to the conclusion that Stylolites were merely segregations, which owed their shape and origin to fossils lying in the soft mass of limestone during consolidation. Huot, in 1842, described specimens of this structure from the Jurassic of the Crimea, and expressed the opinion that they were due to crystallization and aggregation.[§] Cotta, in a work published in 1846, compared Stylolites with the ice crystals that form in the soil in winter, and inferred for both a similar origin.[‖] In 1852, Plieninger proposed an original and elaborate explanation, which, notwithstanding its improbability, has since found quite a number of supporters.[¶] He supposed that the surface of the soft limestone was first raised above the water, and on drying became separated into blocks by shrinkage-cracks. Through the action of rain, these were reduced in size, and the columns, protected by shells and other foreign substances, were thus made to assume definite forms. After subsidence, another layer was deposited over this surface, and the whole gradually became compact limestone. The fact that rain, under certain circumstances, may produce columns very similar in form to Stylolites had already been noticed, and this was doubtless one reason why Plieninger's theory gained so many adherents, one of whom appears to have been Quenstedt,[**] who had himself long before so nearly cleared up the mystery. In a later work however, he presents again his original explanation with some modifications, which make it, although still crude and incomplete, much more satisfactory than any previously offered.[††] Von Alberti, in 1858, suggested still another hypothesis. Having observed Stylolites covered with a dark substance which he regarded as bitumen, he expressed the opinion that the columns were formed by drops of petroleum pushing their way upward through the soft rock.* One of the latest writers on the subject is Von Meyer, who claims that Stylolites are due to the crystallization of gypsum, as he had detected columns coated with that substance.†

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* Report on the District adjoining the Erie Canal, p. 134.

† Silliman's Journal, Vol. XX., p. 74.

‡ Second Annual Report on Geology of N. Y., p. 271, 1838, and Final Report p. 107, 1842.

§ Report on 4th District of N. Y., p. 96.

‖ Report on 2d District of N. Y., p. 111.

¶ Geology of Canada, p. 632, 1863.

** Beitrage zur Min. u. Geol. Kenntniss der Mark Brandenburg, I. p. 58.

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[*] Versteinerungen der Mark Brandenburg, p. 288. Berlin, 1834.

[†] From *στυλοσ*, a column.

[‡] Wiegmann's Archiv., V. p. 137, also Jahrbuch der Mineralogie etc., p. 496, 1837.

[§] Voyage dans la Russie merid. II. p. 369.

[‖] Grundriss der Geologie, p. 128.

[¶] Würtemberg. Naturwissenschaft. Jahresheften, B. VIII. p. 78.

[**] Petrefacten Kunde, p. 505.

[††] Epochen der Natur, p. 198.

This brief synopsis of the most important literature on this subject is sufficient to show that the question under consideration is one of no little interest. It will, moreover, be at once evident to any one who has made a careful study of Stylolites that many of the explanations proposed are based on merely local peculiarities, or unessential features of the structure; and hence, even if true in the instances cited, would not account for it elsewhere. A comparison, however, of the various forms of this structure, as they occur in different formations, and at widely separated localities, clearly shows that all have been produced by some common cause, which was not dependent on local influences or conditions. The subject of the present paper was to prove that this structure in all its various modifications was simply the result of *pressure.* The author had carefully examined many typical localities in this country and in Europe, and found at each conclusive evidence in favor of this explanation, which satisfactorily accounts for all the known phenomena of the structure.

If any characteristic locality of Stylolites be examined with care, it will readily be seen that a displacement took place in the rock before consolidation was completed. It will, moreover, not be difficult to perceive that when the columns stand at right angles to the stratification, they have been produced by vertical pressure, resulting from the weight of the superincumbent strata; and that the comparatively few suture joints having a different position are due to lateral pressure.

Although all the separate columns show indications of having been thus made by pressure, this origin becomes unmistakable if we examine the more perfect ones, especially those from a homogeneous, fossiliferous limestone, such e. g. as the Muschelkalk of Northern Germany, or the Clinton limestone at Lockport, and other points in Western New York. When the Stylolites are well developed in such a rock, it will generally be found that the columns start from the junction of two beds of limestone, separated by a thin seam of argillaceous shale.

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* Würtemberg. Naturwissenschaft. Jahresheften, p. 292.

† Neues Jahrbuch für Mineralogie etc., 1862, p. 590.

Nearly all the separate columns, moreover, have on their summits *a fossil shell, or the inorganic substance, which has accurately determined their shape*, and above this a rounded or pointed cap of shale, evidently identical with the layer already mentioned, and separated from it when the strata settled during consolidation. The longer columns will usually have the convex side of the shell uppermost, and the shorter columns the reverse. When the shell lies obliquely on the column, the latter will, in most cases, be found curved, the degree of obliquity of the shell clearly determining the amount of curvature.

From these and other similar facts it will not be difficult to ascertain how these striated and capped columns were formed, although the mystery could scarcely have been solved from a study of imperfect Stylolites, such as occur in most formations. Let us first suppose a quantity of fine carbonate of lime, sufficient when consolidated to make a thick bed of limestone, slowly deposited under water; and, while still, soft shells and other organic substances scattered over it, and the whole then covered with a very thin layer of argillaceous mud. If, after this, the deposition of calcareous matter proceeds, gradually forming a second bed, its increasing weight will slowly condense the bed below. The shells beneath the clay layer will offer more resistance to the vertical pressure than the material around them, and hence the latter will be carried downward more rapidly, thus leaving columns projecting into the bed above, each protected by its covering, and taking its exact shape from its outline. That this must have been essentially the method of formation, every typical locality of Stylolites, if carefully studied, will afford ample evidence.

The immediate cause of the formation of columns under the above circumstances is clearly a difference of resistance to the pressure between the shell, supported by the material beneath it, and the surrounding mass. The reason why the shell resists the pressure more effectually than the substance around it may be owing, first, to its form, which, when its convex side is upward, enables it to act as a wedge, thus overcoming in part the cohesion of the material above it; secondly, to its weight, which would slightly condense the plastic mass beneath it, and thus secure a more firm support; or, thirdly, to its being an organic substance, which, like the nucleus of a concretion, has attracted to itself and consolidated the particles of carbonate of lime beneath it, but not those above, owing to the intervening argillaceous layer. Any one of these causes would, doubtless, be sufficient to produce the superior density required to start a column, and this would at once have its farther progress facilitated by a cap of mud formed above the shell, thus rendering the summit of the column more convex, and hence diminishing the effective pressure. If, however, the concave side of the shell be uppermost, this assistance is in a measure lost, as the cavity of the shell must first be filled from the argillaceous layer before the column can secure a convex summit. Hence such columns are usually shorter than those which have the shell reversed.

If the shell, instead of lying horizontal, as in the above instances, has an oblique position, curved columns will generally be formed, the curvature being toward the upper edge of the shell, and its amount depending upon the degree of elevation. Where the rock is not homogeneous, bent or even broken columns often occur, evidently caused by meeting with impediments, just as a nail is turned from its course when driven against an obstacle. To carry out the simile, the columns with the oblique shells curve towards the sharp edge of the summit exactly as a horseshoe nail bends outward when driven into the hoof, and for precisely the same reason.

The comparatively few Stylolites extending from the upper layer of limestone into the lower are evidently formed in essentially the same way as those already described, although under somewhat different circumstances. Where the shape has been determined by a fossil, it will generally be found that this was deposited above the argillaceous layer rather than below it. The cause of the superior density required will readily be inferred from what has been stated above.

The foregoing explanation has been mainly suggested by a study of the more perfect, separate columns, which usually appear to be formed under essentially the circumstances already mentioned. Where, however, the conditions are less favorable, columns and elevations, more or less regular in shape, may still be formed, and such alone are to be found at most localities. To this class clearly belong the specimens described hitherto by the distinguished geologists who have investigated the subject in this country, and the same holds true, almost without exception, of those examined by foreign authors. Such specimens, viewed in the light of the more perfect columns, often show indications of their origin from pressure; but as the crowning shell — the key to the mystery — is wanting, they alone would hardly reveal the mode of their formation, and hence it is by no means strange that their unessential features should have been made the basis of so many theories of explanation.

The oblique suture joints, already alluded to, are clearly due to the same general cause as the more perfect Stylolites. Those that cut the strata at a high angle evidently owe their origin to lateral pressure, acting along a plane of fracture, and thus driving into each other the irregular adjoining surfaces. Such joints are not uncommon in the water-line of Monroe County, N. Y., and a characteristic example is figured in Prof. Hall's final Report.* The same rock contains an abundance of imperfect columnar Stylolites, such as usually occur in a homogeneous nonfossiliferous limestone.

In addition to the varieties of Stylolites already mentioned, many others may be found at nearly every typical locality. Not merely foreign substances alone, but even any inequality in the density of the plastic strata will prevent a perfectly uniform settling of the whole, and also accurately register the amount of interference thus occasioned. In this way striæ and rude indications of columns are often formed along seams, or even in the body of the limestone itself. So also where the argillaceous layer is thick, and the limestone not homogeneous, rounded elevations and depressions will be formed along the planes of junction. Examples of this are common in the Trenton as well as in the corniferous limestones of New York.

Where concretions are imbedded in shale, as in the Hamilton group of Western New York, their sides will not unfrequently be found striated like the sides of Stylolites, clearly due to the sliding motion of the surrounding rock. When this takes place before the concretions are fully completed, very peculiar forms are often produced. Where the strata of shale themselves have been disturbed and distorted before consolidation was entirely finished, they are often fractured in various directions, and the adjoining surfaces of the fragments finely polished by the pressure of the disturbing force. Examples of this may be seen in the Hudson River slates at Cohoes, N. Y., and at other points on the Mohawk. Where the rock becomes nearly or quite solid before fracture, the well-known "Slickensides" are formed, which every one admits are merely friction-marks, due to the pressure or motion of adjoining surfaces, as their mode of formation may often be detected while still in progress. Such examples, however, constitute one end of a series extending with many intermediate gradations through the forms just described up to the perfect columns of the Stylolites with their characteristic covering, all clearly owing their origin to one common and simple cause.* The series might, perhaps, be extended even farther, so as to include the structure known as "Cone-in-Cone," which, according to the investigations of the author, is probably due to the action of pressure on concretionary structure when in process of formation. Intermediate forms between Stylolites and Cone-in-Cone had been observed by the author, and also some other similar structures, the origin of which he hoped to discuss in a future paper.

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* Geology of N. Y., Fourth District, p. 131.

Whenever displacement of any kind takes place in strata, the adjoining surfaces that thus move past each other do not usually again firmly unite; and hence various substances are often introduced by infiltration into the intervening spaces. In this way the surfaces of Stylolites and the enclosing rock not unfrequently become covered with oxides of iron, either in the form of deudrites, or of a uniform coating. Carbonate of lime, or of lime and magnesia, sulphate of lime, and of strontia when introduced, in this manner often crystallize in the grooves on the sides of the columns or sutures, thus apparently forming fibrous crystals; and consequently, these have, perhaps not unnaturally, been regarded as essential elements in the formation of Stylolites by those who had made but a limited study of the subject. Hence the various crystallization theories that have been proposed, each regarding the particular substance detected as the cause of the structure. The dark coating on columns and in sutures, which has been considered bitumen by several authorities, will generally be found, on examination, to be either a portion of the argillaceous layer, separated by the Stylolites when forming, or, as in the case of Slickensides, merely a portion of the rock, finely divided and compressed. The dark color may, of course, be heightened by the subsequent infiltration of organic substances, but the coating itself is in nearly all cases essentially inorganic.

The localities of Stylolites in this country are very numerous, and allusion has already been made to some of the more important. The most interesting one known to the author is in the Clinton limestone at Lockport, N. Y., where nearly all the perfect columns are crowned with fossils. The best exposure at this locality, now accessible, is at Cady's quarry, a few rods below the railroad bridge over the canal;

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* A suite of specimens, from various localities in this country and in Europe, illustrating such a series, was exhibited by the author.

but the terrace of limestone on which this part of the city is built contains throughout its whole extent fine illustrations of this structure. Apparently the same beds are exposed in the railroad cutting on the Niagara River above Lewiston, nearly twenty miles distant, as layers having essentially the same position, and containing similar Stylolites, have been observed by the author there and at various points where the Clinton crops out along the "Mountain" ridge; and Dr. A. M. Leonard, of Lockport, has since discovered other intermediate localities, which render the connection more than probable, thus indicating a very large extent of surface, over which the same peculiar causes were in operation at the same time.

Besides the localities already referred to, many others of interest occur in the Silurian, Devonian, and Carboniferous, and more rarely in the Triassic. In New York and Canada the Niagara and Corniferous limestones often contain imperfect Stylolites in abundance, while in the West fine illustrations of the structure have been found in the subcarboniferous. Special localities may readily be ascertained by consulting the various State Geological Reports.

One of the most interesting localities of Stylolites in Europe is that already mentioned in the Muschelkalk at Rüdersdorf, near Berlin, where this structure is developed in great perfection. Nearly all the separate columns are capped with fossils, and a great variety may easily be obtained. During a visit to the locality in 1864, the author collected more than fifty characteristic columns, each having an organic covering, and among these ten species of fossils were represented. The Muschelkalk and Zechstein in other parts of North Germany also frequently contain Stylolites in abundance. In Würtemberg, columns with a black coating are common in the Muschelkalk near Friedrichshall, and at Rottweil Stylolites are occasionally found having on their summit a fossil crab.* Various localities of Stylolites have been observed in France, one of the most important of which is in the Jura near Dijon, where columns a foot in length were noticed by M. d'Aoust.† In Great Britain this structure appears to have attracted very little attention, and no localities of particular interest have been described. In the subcarboniferous limestones of Ireland the author had observed the more common varieties of Stylolites at several places, but the structure was nowhere well developed.

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* Von Alberti. Überblick über die Trias, p. 15.

† Bulletin Soc. Geol. de la France, Vol. III. p. 327.

## II. PALÆONTOLOGY.

### 1. ON SOME FOSSIL REPTILES AND FISHES, FROM THE CARBONIFEROUS STRATA OF OHIO, KENTUCKY, AND ILLINOIS. By J. S. NEWBERRY, of New York, N. Y.

THE specimens exhibited and described in this communication consisted of reptiles and fish from the cannel stratum underlying the main coal seam at Linton, Ohio, of fishes from the coal measures of Illinois, collected by the State Geologist, and of a group of fishes collected by Dr. Patterson from a stratum of bituminous shale, lying in the Waverley group, one hundred and twenty-five feet above its base, at Vanceburg, Kentucky. Of these, the first series included *Raniceps Lyellii*, Wyman, with several as yet undescribed reptiles, some of which apparently belong to Prof. Huxley's new genera, *Ophioderpeton* and *Urocordylus*. Associated with these were some twenty species of fossil fishes, most of which have been described by Dr. Newberry, but were now represented by new and more perfect specimens. Among these were eight species of *Eurylepis*, a genus created by Dr. Newberry to receive a group of small lepidoids, allied to *Palæoniscus*, but distinguished by the scales of the sides which are much higher than long. The scales on several of these species are very highly ornamented. The specimens exhibited were preserved in cannel coal, and covered with a film of sulphide of iron, by which they were brilliantly gilded. With these were two species of *Cœlacanthus*, some of the specimens of which showed that the fishes of this genus were furnished with a supplemental caudal fin, as in *Undina*. This Dr. Newberry stated was an interesting fact confirmatory of Prof. Huxley's view of the relations of *Undina*, *Macropoma*, and *Cœlacanthus*. The numerous and very complete specimens of *Cœlacanthus* exhibited supply much that was wanting to a perfect knowledge of the anatomy of this genus. The bones of the head are similar in form to those of *Macropoma*, are highly ornamented with tubercles above lines below. The jugular plates are double and long-elliptical as in *Undina* and *Macropoma*. The position and form of the fins are as in *Undina*, but the anterior dorsal is stronger. The fins are supported on palmated interspinous bones, similar, in a general way, to those of the other genera of the family. The paired fins are slightly lobed. The supplemental has been referred to. The scales are ornamented with curved and converging raised lines. In many specimens the earbones (otolites) are distinctly visible. Besides the fishes found at Linton already enumerated, there were scales and teeth of *Rhizodus*, two species, at least, one of which (*R. angustus*) has teeth of two forms, one large, flattened, and double-edged, the other smaller, more numerous, slender, sheathed, and conical, with a circular section throughout; two species of *Diplodus*, consisting of bony base and enamelled crown, — the latter distinctly and beautifully serrated, — so that there can scarcely be a question that they were teeth, and not, as claimed by Mr. Atthey, of Newcastle, England, dermal tubercles. In the Linton fauna is one species of *Palæoniscus (P. scutigerus. N.)*; one of *Pygopterus*; one of *Megalichthys*, represented by scales; and numerous spines of placoid fishes of the genera *Compsacanthus* and *Pleuracanthus*.

The fish remains from Illinois consisted of a splendid specimen of *Edestus vorax* (Leidy), from the coal at Belleville, opposite St. Louis, and of several individuals of a new species of *Platysomus* from the concretions of iron ore at Mazon Creek. The *Edestus* was said by Dr. Newberry to have been described as a jaw, but the specimen exhibited was much more complete than any before found, and there could scarcely be a doubt that it was the spine of a Selachian. *Platysomus*, he said, though common in the coal measures of England, had not been before found in America.

The fishes from the Waverley were from a new locality, and from a horizon that had furnished very few fossils of any kind, and no fishes except a *Palæoniscus (P. Brainerdi)* found in Northern Ohio. The specimens collected at Vanceburg by Dr. Patterson consisted of teeth of *Cladodus* and *Orodus*, with spines of *Ctenacanthus*, with the tail of one of these Selachians distinctly preserved. This, Dr. Newberry said, was a great rarity, as the soft, and even the cartilaginous parts of plagiostomous fishes had usually disappeared, the teeth, spines, and dermal tubercles, the only bony parts, remaining. The only similar cases, of which he had any knowledge, was the discovery of the tail and fins of Chondrosteus in the Lias of Lyme Regis, England, and the preservation of *Thyalina* in the Solenhofen slate. The specimen shown was greatly older, being from the base of the carboniferous, and was the only figure that Nature had given us of the external form of these ancient sharks. This tail was very heterocercal, had the from of the caudal fins of some living sharks, and indicated a fish of seven or eight feet in length. In the specimen exhibited the vertebral column had entirely disappeared, but the impressions of the spinous bones were distinctly visible, those of the lower lobe of the tail being ossified throughout. Dr. Newberry said that he hoped to gather data from this collection for uniting teeth and spines, which, though described under different names, were parts of one fish.

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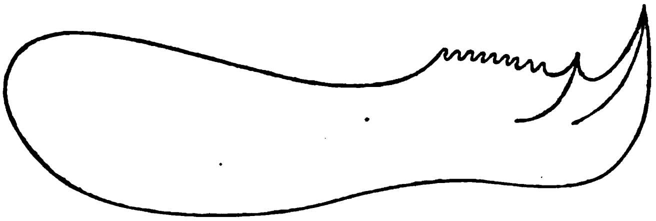
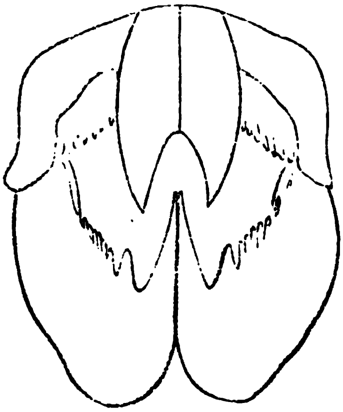
## 2. On some Remarkable Fossil Fishes, Discovered by Rev. H. Herzer, in the Black Shale (Devonian) at Delaware, Ohio. By J. S. Newberry, of New York, N. Y.

Dr. Newberry exhibited to the section different portions of the head of a gigantic fish, to which he had given the name of *Dinichthys Herzeri,* and which, he said, from its size and structure, deserved the same distinction among fishes that *Dinotherium* and *Dinornis* enjoy among mammals and birds. Most of the bones obtained as yet belonged to the head, which was over three feet long, by one and a half broad, and wonderfully strong and massive. All parts of the head had been procured, and many different individuals were represented in the collections made by Mr. Herzer. The cranium was composed of a number of plates firmly anchylosed together and strengthened near the occiput by internal ribs, or ridges, nearly as large as one's arm. The external surface was covered with a very fine vermicular ornamentation. The anatomical structure was more wonderful than the size, and was such as to separate this quite widely from any fishes known, living or fossil. The most marked peculiarity was in the structure of the jaws and teeth, both as regards the form and texture. The form of the jaws will be best understood by the following figures: —



Mandible one-eighth natural size.



Upper and lower jaws in position restored.

The head terminated anteriorly and above in two great incisors, representing the pre-maxillary, behind which, on either side, were the maxillaries, broad, flattened bones of very dense tissue, along the lower edge of which was set one row of small, robust teeth, which were neither implanted in sockets nor cemented to the jaw, but were formed by the consolidation and prolongation of the jaw tissue. The mandibles are over two feet long by six inches deep, laterally flattened and very massive, being without any medullary cavity. The anterior extremity was turned up in a huge triangular tooth, composed of dense, ivory-like tissue, which articulated with (passing between) the divergent incisors of the upper jaw. Back of this terminal tooth, on some specimens, was another triangular summit, behind which was a row of small teeth, corresponding to those of the maxillaries. Such was the power of this tremendous dental apparatus, that the bodies of our largest living fishes would be instantly pierced and crushed by it, if exposed to its action. Behind the head were large and thick plates, one of which corresponded to the "*os medium dorsi*" of *Heterostius* (Pander); being at least of equal size.

These interesting fossils were found in the calcareous concretions, which occur so abundantly near the base of the "Black Shale" (Hamilton) at Delaware, in Central Ohio, by Mr. Herzer, a clergyman, who, while performing his pastoral duties, and living on a very small salary, had been a most zealous and remarkably successful student of the local geology.

## III. ZOÖLOGY.

### 1. ON THE ZOÖLOGICAL AFFINITIES OF THE TABULATE CORALS.

By A. E. VERRILL, of New Haven, Conn.

THE various kinds of coral-like structures are now well known to be produced by several very different classes of animals, and also, in some cases, by certain low plants. Thus we may have Molluscan corals *(Bryozoa)*; Corals of Halcyonoid Polyps *(Tubipora, Gorgoniæ,* red-coral); Corals of Madreporian Polyps *(Madrepora, Porites, Astræa, Mœandrina)*; Corals of Actinoid Polyps *(Antipathes,* etc.); Hydroid Corals *(Sertularia, Millepora)*; Protozoan Corals *(Polytrema* and various other stony sponges, *Eozoon* and other *Foraminifera)*; Vegetable Corals *(Nullipora Corallina,* etc.).

Although the nature of most of the living forms is now pretty well known, it is often very difficult to decide upon the affinities of various fossil forms, which have no living representatives. And since coral-like organisms are, next to shells, the most abundant and characteristic fossils in many formations, it becomes a matter of great interest to ascertain their true position in the Animal Kingdom. The periods when certain classes and orders of animals first appeared in geological time will, also, be materially changed by diverse interpretations of the affinities of fossil corals.

Among the most important doubtful groups, at the present time, are the Cyathophylloid Corals and the Tabulate Corals *(Zoantharia Rugosa* and *Zoantharia Tabulata,* Edwards and Haime). The former are referred by Milne Edwards and Haime, and most other writers, to the Madreporian Polyps, but as a distinct family, tribe, sub-order, or order, by different authors. Certain writers, however, have referred several of the genera to the mollusca, near *Hippurites.* But Prof. Agassiz refers the entire group, together with the *Tabulata,* to the Hydroids.*

The Tabulate Corals were introduced among the Madreporian Corals by Prof. Dana, in whose excellent work they form only a distinct group, but the genera were arranged according to characters other than the existence or absence of transverse plates. By Edwards and Haime they were united into one group, on account of this one structural character, the importance of which is very doubtful. Some of the Tabulate genera have also been referred elsewhere. Thus Rominger* has endeavored to prove that *Chætetes* and allied forms are *Bryozoa*, and Dana referred *Aulapora* and *Syringopora* to the Alcyonaria.

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* Proceedings of the Boston Society of Natural History, Vol. VI. p. 373, 1859. Contributions to the Natural History of the United States, Vol. III. pp. 61–3 and IV. pp. 292–6 and 338.

Prof. Agassiz observed the living animals of *Millepora* at the Florida reefs, and found that the larger cells are occupied by animals different from those that form the small ones scattered between them, and that both kinds correspond with the polymorphous individuals that form the compound colonies of many kinds of Hydroids. In the animals of *Millepora*, as figured and described by Prof. Agassiz, the mouth is at the prominent extremity of the long, slender, or clavate body, and the short, capitate tentacles do not form a circular wreath around a distinct oral disk, but are clustered around the upper part of the body in an irregular manner. The tentacles, like the whole body, have the Hydroid characters well marked.†

Finding the tabulated *Millepora* a well-characterized Hydroid, Prof. Agassiz very naturally referred all other *Tabulata* to the same order, although among them there are several distinct types of structure, very different from *Millepora*. On account of the existence of transverse plates or septa in many *Rugosa*, he supposed that this group would also prove to be Hydroids. As there are no living representatives of these, it will be very difficult to determine their true nature with certainty, but there are apparently many good reasons for retaining them among the true *Polypi*. Many of them, also, do not present transverse septa, while the radiating septa are often highly developed, indicating that the body of the animal was divided up into radiating chambers, a feature not found among Hydroids, but most characteristic of the true Polyps.

Among the tabulated corals, we find two well-marked groups. The first includes *Millepora* and *Heliopora* among living corals, *Heliolites*, and many other fossil genera. In these there are nearly circular, tubular cells, separated by a porous cœnenchyma, in which there are smaller cells, which sometimes form circular clusters around the larger ones. The two forms of the cells indicate the dimorphous character of the animals forming them, which is a common if not characteristic feature of many families of Hydroids.* The cells themselves are divided transversely by more or less numerous plates, but the radiating septa are either entirely absent or represented only by slightly raised lines upon the walls of the cells or the upper surface of the transverse septa.

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* Proceedings of the Philadelphia Academy of Natural Sciences. 1866, p. 118.

† Prof. C. Fred. Hartt informs me that while collecting specimens of *Millepora* (*M. alcicornis L.*, *M. nitida V.* etc.) at St. Thomas and on the coast of Brazil, they stung his hands severely in parts where the skin is tender, unless handled with great care. This, also, is a character of the Hydroids rather than of the true Polyps. A large Hydroid was observed by Mr. Bradley at Panama to have the same power.

The second group, including Pocillipora and Seriatipora, among living corals, and Favosites, Columnaria, etc., among fossil ones, contains genera that have the cells all similar, and usually united directly together by the distinct walls, or a compact cœnenchyma. In these the transverse plates are usually quite as regular and complete as in the first group, or even more so, but the radiating septa are also frequently very well developed, forming cycles of six, twelve, twenty-four, or other multiplies of six, precisely as in the Madreporians, and in some cases these extend inward from the wall, so as to join a central columella. In some species of Pocillipora † there are twelve radiating plates, as well developed as those of many true Madrepores.

Hoping to gain some positive evidence upon this question, Mr. F. H. Bradley, while collecting specimens at Panama for the Museum of Yale College, was requested to examine the living animals of *Pocillipora capitata* V., which occurs in that region quite commonly. This he was able to do without much difficulty, since the polyps of *Pocillipora* are tolerably large and expand readily in confinement, differing greatly in both these respects from those of *Millepora*. Although provided only with a good pocket lens, his observations and drawings are of importance with reference to the question under discussion. A careful microscopic examination is, however, still very desirable. According to his drawings and descriptions, this *Pocillipora* has exsert polyps, with twelve equal, round, moderately long, tapering tentacles, which surround the edge of the oral disk in a single circle, six being ordinarily held upright, while the alternate six bend outward. Twelve radiating lines, considered to be the edges of the internal radiating lamellæ, showing through the translucent disk, pass from between the bases of the tentacles to the stomach. Thus these animals have all the external characters of those of *Porites* and *Madrepora*. Indeed, Mr. Bradley states that when comparing the expanded polyps of the *Pocillipora* and a species of *Porites*, living with it, and placed side by side, he could see no difference except in the color and posture of the tentacles, those of the *Porites* being held all in the same position. From these observations it seems necessary to conclude that *Pocillipora*, and other *Tabulate Corals* belonging with it, are true Madreporian Polyps, allied to the *Poritidæ* in some characters, and to *Stylophoridæ* in others,* but forming two or more distinct families.

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* Dimorphism among true Polyps is known only in the *Penatulacea*, and in the genus *Sarcophyton*, among the *Alcyonaria*, unless the terminal polyps of *Madrepora* be considered a dimorphous form.

† *Pocillipora stellata* Verrill, from Zanzibar, is a good example.

If these conclusions be well founded, the *Tabulata* form an artificial and unnatural group, which should be dismembered and the various genera distributed between the Hydroids and Madreporian corals, in accordance with other and more important characters.

## 2. CONSIDERATIONS DRAWN FROM THE STUDY OF THE ORTHOPTERA OF NORTH AMERICA. By SAMUEL H. SCUDDER, of Cambridge, Mass.

THE Orthoptera of North America have received, as yet, but little attention. Those of New England alone have been carefully enumerated. Any comparison, therefore, of the Orthoptera of Europe and America must be based, so far as this continent is concerned, on our knowledge of the New England fauna. This limited region has a numerical preponderance of species over any European district of equal extent with which it can fairly be compared. Situated in the latitude of Southern Europe, the climate and physical features of New England bear a stronger resemblance to the Scandinavian peninsula than to any other part of Europe. Yet New England possesses seventy-nine species of Orthoptera, and Northern Europe has scarcely more than half that number, viz., forty-three. In point of numbers, the Orthoptera of New England stand midway between those of Northern and Middle Europe, the latter having one hundred and twenty-six species.

A separate comparison of the families brings to light some very interesting features.

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* In the Voyage de l'Astrolabe, Quoy and Gaimard have figured two species of "Pocillipora," both having twelve equal, tapering tentacles. One of these is a *Stylophora*, according to Edwards and Haime, but the other seems to be a true *Pocillipora*.

One-eighth of the species of Forficulina which occur in Europe are found in the northern part, one-half in the middle, and five-eighths in Southern Europe. North America does not seem to be rich in Forficularians. New England possesses but two species, or one less than is found in Northern Europe.

One-fifth of the species of European Blattina occur in the northern part of the continent, one half in the middle, and seven-eighths in Southern Europe, showing a great preponderance of species towards the south. New England has seven species, and stands midway between Northern Europe (five) and Middle Europe (nine).

No species of Mantis occurs in New England, although one species is found in Maryland, and another is described (erroneously?) from New York. In Europe, one species alone extends as far north as Middle Europe. A single species of Phasmida is found in the southern half of New England, but no species occurs either in Northern or Middle Europe; two are described from Southern Europe.

Of Gryllodea, a single or at most two species occur in Northern Europe. Ten species, or two-fifths of those found on the whole continent, occur in Middle Europe, and seven-eighths of the whole number in Southern Europe. In New England there are eleven species.

Of Locustariæ, Northern Europe possesses fourteen species, or two-elevenths of the whole continental fauna; Middle Europe has thirty-nine, or one-half of the whole, while Southern Europe has forty-nine, or five-eighths. In this group we begin to have a more equable proportion, approaching to a balance of species between the North and South. Here, also, New England, which has only sixteen species, is more closely allied to Northern Europe. New England, however, cannot always be taken as a representative of the whole continent; for America is extremely well supplied with species of this family, and peculiarly so in the case of certain genera.

Twenty species of Acridiodea, or more than one-fourth of the whole continental fauna, are indigenous to Northern Europe. Middle Europe has fifty-five species, or five-eighths of the whole number, while Southern Europe possesses only fifty-one. This shows that the family affects the more temperate regions. It is the only family of Orthoptera in which there is a preponderance of species towards the North. New England, however, contrary to what we should expect from our comparison of the Locustariæ, is extremely rich in forms of this family, forty-two species being found within its limits. The other portions of America are almost equally rich.

The following genera of Orthoptera occur in New England, and are unrepresented in Northern and Middle Europe: Diapheromera, Panchlora, Platamodes, Ceuthophilus, Cyrtophyllus, Microcentrum, Tragocephala, and Tettigidea. Very many more, including many genera yet undescribed, might be added from other parts of North America. On the other hand, Onconotus, Orphania, Odontura, Saga, Locusta, and Decticus, which occur in Northern and Middle Europe, will be vainly sought for in New England. The genera Forficula and Stenobothrus are much more richly developed in Northern and Middle Europe than in New England.

Going beyond the limits of New England, we shall find in Europe but one or two representatives of the sub-family which includes Hadenœcus, or the genus of Orthoptera, found in the caverns of Austria and Kentucky, while America contains many genera, and very many species, especially in the genus Ceuthophilus. Conocephalus is also richly developed in America. I am acquainted with nearly twenty species, while only one species is found in Europe. Finally, oedipoda and the family of minute Tettigideans are much more abundant in America, and even in New England alone, than in the whole continent of Europe.

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## 3. The Embryology of Libellula (Diplax) with Notes on the Morphology of Insects and the Classification of the Neuroptera. By A. S. Packard, Jr., of Salem, Mass.

This paper embraces a description of the egg and the evolution of the embryo, of which seven successive stages are described.

These stages are represented by the following steps: 1°, The formation of the anterior part of the head, the ventral wall of the thorax, and the formation of the mouth-parts and thoracic appendages.

2°, The appearance of the rudiments of the eyes. The appearance of the abdomen. This stage is compared with the embryo of the spider, as worked out by Claparède, and of the crawfish, as studied by H. Rathke.

3°, The differentiation of the head into the eye-bearing piece, the epicranium and clypeus, and the approximation of the fourth pair of appendages destined to form the labium. The appearance of the rudiments of the anal stylets. The closure of the dorsal wall of the body over the yolk mass. The three divisions of the body into head, thorax, and abdomen have now become distinct.

4°, The appearance of articulations in the appendages. The labium rests flat upon the under side of the body, the articulations of the thorax and abdomen appear, and there is a greater equality in the size of the three regions of the body than before. Appearance of the nervous ventral cord. Formation of the tracheæ and alimentary canal.

5°, Lepisma-like stage. 6°, Thickening of the abdomen. The labium is raised from the breast towards the mouth.

7°, Description of the newly-hatched larva, and its transformations. General conclusions.

## 4. The Insect Fauna of the Summit of Mount Washington, as compared with that of Labrador. By A. S. Packard, Jr., of Salem, Mass.

The following notes are thrown together rather to furnish a summary, from data only approximately correct, of our present knowledge of the distribution of Alpine and Arctic Lepidoptera, than to give anything like a complete account.

The summit of Mount Washington, or that portion lying above the limit of trees, agrees in its climate and other physical features very closely with those of the coast of Northern Labrador, as observed at Hopedale, in latitude 55° 35′.

The seasons correspond very exactly, as the snow melts in the early summer, and ice is formed early in the autumn at about the same dates.

As is well known, the Alpine flora of the White Mountains is identical with that of the arctic regions, which extends far southward along the Atlantic shore of Labrador. Not only is the flora identical so that no species of plant is known to be restricted exclusively to our Alpine summits, but the times of leafing, of flowering, and fruiting of plants is much the same. Such was observed in the *Rubus chamæmorus* and *Arenaria Greenlandica,* for example.

It is also the same apparently with the fauna. The *Chionobas semidea* flies late in July and early in August, in greatest abundance, at the same time that its representative species swarm over the bare, rocky hill-tops of the Labrador coast. Their appearance heralds the close of summer, both on the extreme summit of Mount Washington and the exposed hills of Labrador.

Most is known of the Lepidopterous fauna of Alpine and arctic regions, both in America and Europe, and our data will be drawn from this group of insects. In Europe, Thunberg, Zetterstedt, Duponchel, Boisduval, Staudinger, and Wocke, have studied the circumpolar lepidopterous fauna; Möschler and Christoph, Clemens and Scudder and the writer, have described the insects of Labrador, and Messrs. Scudder, Shurtleff, and Sanborn have explored the insect fauna of Mount Washington, and other Alpine summits.

According to Dr. Staudinger, out of sixteen butterflies found in Finmark, two only (*Erebia Manto* and *Argynnis Thore*) occur in the Alps and also in Siberia. But two or three butterflies, among them *Chionobas Aello*, so far as we have been able to learn, are peculiar to the Alps. Of 122 species of lepidoptera inhabiting Labrador, 70 are found only in Labrador and Arctic America, while 43 are circumpolar, namely, occur on both sides of the Arctic Ocean, being found in Finmark and the mountains of Norway; six species inhabit the summit of Mount Washington, and five of the whole number also inhabit the Swiss Alps. Two of the European Alpine species are found on Mount Washington, New Hampshire. The following table gives a summary of the distribution of the species of the different families.

## DISTRIBUTION OF LABRADOR LEPIDOPTERA.

| NAMES. | Circumpolar. | Labrador and Arctic America exclusively. | Alps. | Mt. Washington. |
|---|---|---|---|---|
| Butterflies . . . | 5 | 8 | | |
| Bombycidæ . . | 1 | 2 | 1 | 1 |
| Noctuidæ . . | 19 | 13 | 4 | 2 |
| Phalænidæ . . | 10 | 16 | | 2 |
| Pyralidæ . . . | 3 | 10 | | |
| Tortricidæ . . | 8 | 14 | | 1 |
| Tineidæ . . . | 2 | 7 | | |
| Total . . | 43 | 70 | 5 | 6 |

Certain genera among insects, as among Mollusca, are almost exclusively arctic. Such are *Chionobas* and *Anarta*, which are paralleled by the two marine genera *Astarte* and *Buccinum*.

Two species *Lycaena Aquilo* (*Polyommatus Franklinii*) and *Cidaria polata*, abounding in Labrador and the polar regions, have not yet been found on Mount Washington. This is paralleled by the occurrence of certain mollusca, e. g. *Leda truncata*, in the high arctic seas, which have become extinct in the seas southward, where they are now found fossil; so that the distribution of the arctic insect fauna seems to be paralleled by that of arctic marine invertebrates. As in the temperate seas certain abysses and banks swept by the arctic currents are peopled by outliers of an arctic marine fauna, so the Alpine elevations or atmospherical abysses, rising out of a temperate into an arctic climate, seem peopled by outliers of an arctic land fauna. These outliers are relics of an arctic fauna, that during the early part of the Quaternary period, i. e. the Glacial Epoch, peopled the surface of the temperate zone.

We cannot suppose a special creation of organized beings for the Alpine summits. *Chionobas semidea* and *Argynnis montinus*, thus far only known to inhabit the summit of Mount Washington, may still be found northward; or, if not, probably became extinct north, finally localizing themselves on the single peak where they now occur. On the other hand the occurrence of *Chionobas Chryxus* Doubld. on Pike's Peak, and *Chionobas Nevadensis* Boisd. found in Nevada, is in favor of those species being autochthonous, though they may yet be found northwards towards the arctic circle.

The Zygænidæ are represented in arctic Europe and the Alpine summits by *Zygæna exulans;* but this is not a circumpolar or arctic species. No member of this family, or of the Sphingidæ or Ægeriadæ is circumpolar or found in Arctic America.

Of the *Bombycidæ* but one species, *Arctia Quenselii* is circumpolar, being found in Finmark and Labrador, and also on the Alps and Mount Washington. An allied form, if it be not a mere variety of this variable species, *A. cervini* Guènee, is found on the Alps.

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* Since publishing the View of the Lepidopterous Fauna of Labrador (Proceedings Boston Soc. Nat. Hist. Jan., 1867), I have received a valuable collection of arctic moths from Dr. Staudinger, which have enabled me to compare the Labrador species more satisfactorily with European types.

*Anarta nigro-lunata* Pack. This is identical with *A. melanopa*. Two males, one from Labrador and the other from the summit of Mount Washington, New Hampshire, scarcely differ; the latter specimen is a little larger, and the hind wings are a little more dusky at base, the blackish portion partly including the discal dot, while the black border is a little broader than in the Labrador specimen. A female from the Swiss Alps is still more dusky on the hind wings.

*Anarta leucocycla* Staud. Was found on Mount Washington in July, and is like specimens from Labrador and Lapland.

*Anarta bicycla* Pack. is identical with *A. melaleuca* (Thunberg) from Lapland.

Another form, *Orgyia? Rossii,* is found in Arctic America and Labrador; *Platarctia borealis* occurs in Labrador, while a representative species and very closely allied, *P. parthenos,* is found at Lake Superior and the White Mountains.

There are no autochthonous species in Northern or Alpine Europe that seem to offset these two species. Platarctia is a truly American genus, and the affinities of the genus to which *Laria* (*Orgyia?*) *Rossii* belongs are as yet conjectural.

Of the extensive family Noctuidæ, there are thirty-one species found in Labrador. Of these, thirteen are, so far as known, only found in Labrador; about nineteen are circumpolar, or found on both sides of the Northern Atlantic; thirteen have thus far only been detected in Finmark, while four occur on the Alps. Two species have been detected on Mount Washington.

Of the genus *Anarta,* twelve inhabit Labrador (this including A. luteola Grote, discovered at Quebec), twelve live in Finmark; two species, *A. melanopa* and *A. funesta,* inhabit the Alps, and two also the summit of Mount Washington. The European Alpine species are *Anarta melanopa* and *A. funesta,* while *A. melanopa* and *A. leucocycla* live on Mount Washington. *A. melanopa* is circumpolar and Alpine on both hemispheres, while *A. funesta* and *A. leucocycla* are only circumpolar.*

No species is known to us to be exclusively Alpine.

Of the Phalænidæ less is positively known, as the Labrador species have not been so carefully compared with those of Arctic Europe, and several of those described from Labrador may prove to be synonymes of European forms.

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* *Cidaria truncata* Hufn. var. from Iceland. A specimen from Carribou Island, Straits of Belle Isle, belongs to this form, in which the middle of the wing is grayish, not being so dark as the more typical specimens.

*Cidaria aurata* Packard. From the White Mountains and Labrador; is distinct from but allied closely to *C. cæsiata* from Lapland.

*C. abrasaria* H.-S. A specimen from Carribou Island agrees well with a specimen from Iceland sent by Dr. Staudinger.

*Cidaria nigro-fasciata* Packard, from Labrador, is very closely allied to *C. abrasaria* H.-S. found in Finmark and Lapland, and may prove to be a variety of it.

*Melanippe hastata* (Linn). Specimens from Lapland are not distinguishable from M. gothicata Guèn, taken in Labrador.

Staudinger states that of thirty species of this family found in Finmark (which is almost exactly the geographical equivalent of Labrador), three are found in the Alps, and five are polar.

On the other hand, of twenty-six species thus far found in Labrador, ten are circumpolar, and two occur on Mount Washington, leaving sixteen indigenous to Labrador.

Of the distribution of the remaining lepidopterous families what little is known is exhibited in the preceding table.

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## NOTE TO THE PAPER OF J. P. PERRY.

(TO BE INSERTED IN PAGE 134.)

The following brief list of primordial fossils found in Vermont will make the discordance, to which I have alluded, evident. Omitting the Lower Taconic, and reading from below upward, we have:

| | | |
|---|---|---|
| II. | Potsdam Sandstone. | Conocephalites Vulcanus (B.).<br>Conocephalites Adamsi (B.).<br>Brachiopods, several undescribed species.<br>Lingula, probably two species.<br>Crinoids.<br>Scolithus linearis (H.).<br>Fucoids, described and undescribed. |
| I. | Georgia Slate. | Articulates, probably two undescribed species.<br>Conocephalites Teucer (B.).<br>Olenellus Vermontana (H.).<br>Olenellus Thompsoni (H.).<br>Camerella antiquata (B.).<br>Orthisina festinata (B.).<br>Orthis, undescribed.<br>Obolella cingulata (B.).<br>Palæophycus congregatus (B.).<br>Palæophycus incipiens (B.).<br>Chondrites, one or two undescribed species. |
| | Swanton Slate. | Articulates, one or two undescribed species.<br>Atops trilineatus (Em.).<br>Graptolites, several species. |

# TITLES

# OF

# COMMUNICATIONS.*

## A. MATHEMATICS, PHYSICS, AND CHEMISTRY.

1. New Determination of the Distance of the Sun. By Simon Newcomb.
2. On the Velocity of Transmission of Signals by the Electro-Magnetic Telegraph. By B. A. Gould.
3. Cosmogony. By L. Bradley.
4. On the Effect of Sunshine on Fires. By E. N. Horsford.
5. On the Theories of Boussingault and Thenard of the Difference between Stale and Fresh Bread. By E. N. Horsford.
6. Note on the Duke of Argyll's Theory of the Mechanism of the Flight of Birds, with Illustrations, derived from the Trachilidae. By L. E. Chittenden.
7. Remarks on the Law of Winds, with some Account of Progress in the Investigation of the Same. By James H. Coffin.
8. The Geodetic Triangulation of the Coast of New England. By A. D. Bache, late Superintendent of the U. S. Coast Survey. By J. E. Hilgard.

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* The following papers were also read : of some, no copy has been received for publication ; of others, it was voted that the title only should be printed. No notice, *even by title*, is taken of articles not approved.

9. ON ISOTHERMALS AND ABISOTHERMALS. By JOSEPH HENRY.
10. SUGGESTIONS ON THE SCIENTIFIC AND PRACTICAL RELATIONS OF WOOD-SPIRIT. By JAMES HYATT.
11. ON THE USE OF MONTHS FOR DATES. By J. F. HOLTON.
12. ON THE METALLIC THERMOMETER. BY J. F. HOLTON.
13. ON EULER'S UNIVERSAL FORMULA FOR THE SUMMATION OF SERIES. By DAVID TROWBRIDGE.
14. ON ELLIPTIC INTEGRALS BY SERIES. By DAVID TROWBRIDGE.
15. MOLECULAR MOTIONS. By H. F. WALLING.
16. ON THE CONVERSION OF IRON INTO STEEL BY MEANS OF CARBURETTED HYDROGEN. By JAMES HYATT.
17. ON A KNOWLEDGE OF THE SATELLITES OF JUPITER BEFORE THE TIME OF GALILEO. By JAMES HYATT.

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## B. NATURAL HISTORY.

18. ON CERTAIN EFFECTS PRODUCED UPON FOSSILS BY WEATHERING. By O. C. MARSH.
19. ON SOME NEW FOSSIL SPONGES FROM THE LOWER SILURIAN. By O. C. MARSH.
20. ON THE DISTRIBUTION OF THE PRECIOUS METALS IN THE UNITED STATES. By CHARLES WHITTLESEY.
21. ON THE STRUCTURE OF ICE IN ITS RELATIONS TO THE SUDDEN DISAPPEARANCE OF ICE ON LAKE CHAMPLAIN. By E. N. HORSFORD.
22. ON THE GEOGRAPHICAL DISTRIBUTION OF RADIATES ON THE WEST COAST OF AMERICA. By A. E. VERRILL.
23. ON SOME PECULIAR PARASITICAL RELATIONS BETWEEN CRUSTACEA AND RADIATES. By A. E. VERRILL.

24. On the Cretaceous and Tertiary Floras of North America. By J. S. Newberry.

25. On the Geological Relations of the Mastodon and Fossil Elephant. By James Hall.

26. On the Geographical Distribution of the Sediments and of the Fossils in the Hamilton Portage and Chemang Groups of New York. By James Hall.

27. Notes on the Distribution of Limnea Megasoma and Cognate Genera. By L. E. Chittenden.

28. On the Occurrence of Fossil Sponges in the Successive Groups of the Palæozoic Series. By James Hall.

29. On the Value of the Hudson River Group in Geological Nomenclature. By James Hall.

30. Indian Architecture. By Louis H. Morgan.

31. The American Beaver. By Louis H. Morgan.

32. Explanation of a Geological Map of Maine. By C. H. Hitchcock.

33. Remarks on the Coal Measures of Illinois. By A. H. Worthen.

34. The Phenogamous Plants of South Eastern New York. By James Hyatt.

35. Remarks on the Ichthyological Fauna of Lake Champlain. By F. W. Putnam.

# EXECUTIVE PROCEEDINGS

OF

# THE BURLINGTON MEETING, 1867.

## HISTORY OF THE MEETING.

THE Sixteenth Meeting of the American Association for the Advancement of Science was held at Burlington, Vermont, commencing on Wednesday, August 21, and continuing to Monday Evening, August 26.

Seventy-three names are registered in the book by members who attended this meeting. Forty-seven new members were chosen, of whom, however, only twelve have as yet signified their acceptance by paying the annual assessment, and, when practicable, signing the constitution. Seventy-five papers were presented, most of which were read, and some of them discussed at great length.

The sessions of the Association were held in the City Hall and the adjoining Court House. At about 10 o'clock A. M. on Wednesday the members were called to order by the Permanent Secretary, Joseph Lovering, in the absence of Ex-President Barnard, and Prof. J. S. Newberry was introduced as the President of the Association for the year. At the request of the Standing Committee, prayer was offered by Prof. M. H. Buckham of the University of Vermont. After which Hon. Torrey E. Wales, Mayor of the City of Burlington, welcomed the members of the Association, in behalf of the citizens, in the following words:—

MR. PRESIDENT AND GENTLEMEN OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE: —

It is my duty and pleasure on this occasion to welcome you to Burlington. I feel some degree of embarrassment in addressing you these few words of welcome, because I know so little of the history of your Association I have learned, however, sufficient in regard to it to convince me that it merits the sympathy and support of all good men.

Its great aim seems to be to bring together, once in every year, the votaries of science in all its various departments, throughout the country, that they may interchange thoughts and opinions, investigate and discuss questions of scientific interest, and by their union of effort promote the advancement of science.

And this we understand to be the object of the present meeting, and in behalf of the people of Burlington I give you a very cordial welcome to our city. But after the magnificent reception and entertainment which you received from the generous citizens of Buffalo last year, what can the people of Burlington ever hope to do in comparison? Our city is not yet three years old, and has less than ten thousand inhabitants, and possesses few of the attractive features of large cities.

It is now in a condition very similar to that of the young man who commences life with no other capital than his *good name*, but with an inflexible determination to improve his condition.

This is our situation, and the members of this Association, having assembled here, must now accept it. It was rather a surprise to us that you selected this place for your present meeting, but we do not despair of the result, for we know that no place, however small, is devoid of interest to men of scientific culture, and that such men will make their meeting successful whether they receive the aid and sympathy of other men or not.

But the people of Burlington will do their whole duty upon this occasion. They will spare no pains to place at your command whatever they have that will contribute to your convenience or pleasure while you remain. I cannot promise you the sumptuous entertainment that you would doubtless receive in the large cities, but I can assure you that the hospitality of our citizens towards the members of this Association will be limited only by the means at their command. And I can also assure you that our people are deeply interested in the success of this meeting, and are heartily in sympathy with its object; and though most of them are engaged in the ordinary pursuits of life, they, nevertheless, appreciate the value of education, and contribute freely of their substance to its support, and are not unmindful of the presence of your learned body in our city at this time. But among my fellow-citizens there are those who can better appreciate the interests of science, because they, like yourselves, pursue knowledge in the love of it. This occasion will be to them one of special interest, and they will welcome you as friends and co-laborers in the cause of truth and humanity.

Men of science deserve our love and sympathy; for they labor and toil, not for wealth or station, but for the cause of truth alone, and are deserving of the gratitude of mankind, for the unnumbered blessings which they have conferred upon the race. Other men may contend for political place and preferment, but the true philosopher seeks another and purer atmosphere. His is a life of constant study and of intense thought. He finds his pleasure and delight in the contemplation of those sublime truths which God has impressed on all his works. The star above, the blade of grass, the grain of sand upon the seashore, all alike furnish him subjects for earnest thought and meditation, which a life-time of devoted study cannot exhaust.

And now, may this meeting, and all future meetings of this Association, be crowned with perfect success; and may the cause of science ever prosper in your hands. The people of Burlington are deeply indebted to you for the honor you have conferred upon them in this present meeting of your venerable body, and for the happy influences which such a meeting will exert upon this community, and they will ever remember the Sixteenth Annual Meeting of this Association with just pride and satisfaction. And may the members of this Association have equal cause to rejoice over the success of this meeting; and at the close of your labors here, may you carry with you to your homes some pleasant memories of this occasion, and of Burlington.

This address of Mayor Wales was acknowledged by President Newberry, in behalf of the Members of the Association, substantially as follows: —

I should not properly express the feelings of the members of the Association did I not say that they congratulated themselves upon the place selected for this meeting. They could not have selected a more agreeable place, both from its beautiful surroundings and historic associations. I have no fears as to their reception; an excess of hospitality which directs the attention of the members from the regular business of the meeting is out of place. I thank the citizens for their interest in the Association. It was determined to be useful. The functions of the Association are for the encouragement of learning which may be diffused among the people. In such a mission an institution of this kind should be sustained. The advance in scientific knowledge made in this country has been rapid, and I am confident our future will develop other more useful and more startling facts. Of all associations for this purpose, the American is the best. It is in fact the foundation of all.

Modesty prevents many men from coming forward, who could contribute much to the cause of science. It is the object of this organization to draw such out. I hope the Association will flourish and be of greater usefulness and importance to the country.

The Association then proceeded to the election, by ballot, of six additional members of the Standing Committee, according to the requirement of Rule 6 of the Constitution. The names of those chosen are printed elsewhere with the names of the other members of that committee.

The Association voted to hold its next meeting at Chicago, Illinois, beginning on Wednesday, August 5, 1868. The officers elected for the next meeting are: —

Dr. B. A. GOULD, of Cambridge, *President;* Col. CHARLES WHITTLESEY, of Cleveland, *Vice-President;* Prof. A. P. ROCKWELL, of New Haven, *General Secretary;* Dr. A. L. ELWYN, of Philadelphia, *Treasurer.* Prof. JOSEPH LOVERING was elected *Permanent Secretary* for another term of two years commencing with the Chicago Meeting.

Dr. B. A. Gould was appointed to deliver a eulogy on the late Prof. A. D. Bache at the next meeting of the Association.

On Thursday evening a general meeting was held in the Court House at which Prof. Joseph Lovering exhibited his experiments on the "Optical Method of Studying Sound;" and, on Friday evening, a general meeting was held in the Lecture Room of the College Street Congregational Church, when the President, J. S. Newberry, delivered an address on "Modern Scientific Investigation, its Methods and Tendencies."

Many of the members in attendance upon this meeting accepted the private hospitality, generously offered by families in the city of Burlington.

On Saturday, August 24, after a short session of the Sections in the morning, which was continued in the evening, the members of the Association and their ladies, accompanied by many ladies and gentlemen of Burlington, by invitation of the *Champlain Transportation Company,* embarked on board the beautiful Steamer *Adirondack* and visited Port Kent and the Ausable Gorge, near Keeseville. On their return they were bountifully entertained on board the steamer, while moving up and down the Lake and enjoying interesting views of *Willsboro' Bay,* the Islands of *Les Quartre Verts,* and *Juniper Island.* On Monday evening, August 26, the members of the Association had an evening reception at the house of Dr. William C. Hickok. On Tuesday morning, after the adjournment of the Association, about twenty members availed themselves of an invitation, which the Association had received and accepted from the Mount Mansfield Hotel Association, to visit Mount Mansfield. They were met at Stowe by Mr. W. H. H. Bingham and, under his escort, were conducted to the summit of the mountain, where they passed the night, enjoying the hospitality of the Mountain House as well as that of the Mansfield House at Stowe.

## RESOLUTIONS ADOPTED.

THE following Resolutions offered by Prof. Alexis Caswell were, on his motion, referred to the Committee on Weights and Measures of the Association: —

*Resolved,* That the Association reaffirms its earnest and cordial sympathy with legislation tending to the adoption, as soon as may be practicable, of the metrical system of weights and measures.

*Resolved,* That, whereas the gold dollar of the United States bears practically a simpler relation to the metrical system of weights than the gold monetary unit of any other country — and, whereas the present dollar is the unit more extensively used among commercial nations than any other: — therefore, in the opinion of this Association, it is inexpedient to disturb or change, without the most cautious and careful consideration, either the weight or fineness of the existing monetary unit of the United States, viz. the gold dollar.

*Resolved,* That copies of these Resolutions be forwarded by the Permanent Secretary of this Association to the Secretary of the Treasury, the Chairman of the Committee of Finance of the U. S. Senate, and to the Chairman of the Committee of Ways and Means of the U. S. House of Representatives.

The following Report of the Committee on Weights and Measures was read: —

The undersigned, in behalf of the Committee on Weights and Measures, to whom the Resolutions have been referred by the Association, reports a cordial approval of the Resolutions. But, owing to the absence of the majority of the Committee (of whose approval he also feels convinced), he begs leave to ask the concurrence of the Standing Committee, before reporting them to the Association with the recommendation that they be adopted.

(Signed) B. A. GOULD.

The Standing Committee having expressed their concurrence in the Resolutions offered by Prof. Caswell, they were unanimously adopted by the Association.

*Resolved,* That Dr. John Torrey be appointed to fill the vacancy in the Committee on Weights and Measures made by the death of Prof. A. D. Bache.

On the motion of Dr. Henry Wheatland the following Preamble and Resolution were adopted: —

Whereas the cause of science and education has been largely promoted by the recent munificent endowments of George Peabody, Esq., who has appropiated for these purposes an amount exceeding the sum of four millions of dollars: —

*Resolved,* That the American Association for the Advancement of Science cordially tender to Mr. Peabody their sincere thanks for his noble contributions to science, and trust that his highest expectations, in the bestowal of these gifts, will be fully realized, and that these efforts in behalf of human culture and progress will conduce to the increased prosperity and happiness of the American people.

*Voted,* That this Resolution be transmitted to Mr. Peabody by the President of the Association.

*Resolved,* That Dr. B. A. Gould be invited to deliver a eulogy on the late Alexander D. Bache, at the next meeting of the Association.

*Resolved,* That Prof. Joseph Lovering be invited to exhibit at a quarter before eight o'clock on Thursday Evening, August 22, 1867, in the Court House, the apparatus shown by him in connection with his paper on the "Optical Method of Studying Sound."

*Resolved,* That the Association accept with thanks the invitation presented by the Directors of the Champlain Transportation Company to make an excursion in the Steamer Adirondack on Saturday, August 24, to view the Gorge of the Ausable River.

*Resolved,* To accept the invitation of W. H. H. Bingham, of Stowe, to visit Mount Mansfield and the Mansfield House at Stowe, as his guests.

In SECTION B, the following resolution, offered by Prof. O. C. Marsh in behalf of the Sectional Committee, was adopted: —

*Resolved*, That a commission of nine members be appointed by the chairman to examine the Linnean Rules of Zoölogical nomenclature by the light of the suggestions and examples of recent writers, and to prepare a code of laws and recommendations, in conformity with just modern usage, and to be submitted to the Association for their approval at the next annual meeting, this commission to have authority to fill vacancies and to enlarge their number to twelve, if deemed desirable.

Committee appointed by SECTION B. to revise Zoölogical Nomenclature.

J. D. DANA,
JEFFRIES WYMAN,
S. F. BAIRD,
JOSEPH LEIDY,
J. S. NEWBERRY,
J. W. DAWSON,
WILLIAM STIMPSON,
S. H. SCUDDER,
F. W. PUTNAM.

## VOTES OF THANKS.

*Resolved,* That to the Mayor and Common Council of Burlington, for their tender of rooms in the City Hall and Court House for the use of this meeting; to the Trustees of the Congregational Church on College Street for similar kindness; and to the President and Trustees of the College for their courtesy and cordiality, the thanks of this Association are due, and that we accept these favors from City and Church and School in the frank, free spirit in which they were offered, as a symbol of that fraternal union which exists between Virtue, Education, Good Government, and Science.

*Resolved,* That our thanks are due, and are hereby heartily tendered to the Local Committee and to the Local Secretary, for the admirable arrangements they have made, which have facilitated the business of the Association during the present meetings.

*Resolved,* That the thanks of the American Scientific Association be presented to the Champlain Transportation Company for their courtesy and liberality in providing for the Association the delightful excursion to the grand scenery of the Ausable, and for the bountiful collation and charming sail among the islands of the Lake on the steamer *Adirondack.*

*Resolved,* That the thanks of the Association be presented to the Directors of the Vermont Central Railroad, the Rutland and Burlington Railroad, the Vermont Valley Railroad, the Rennselaer and Saratoga Railroad, and the Lake Champlain Transportation Company, for their liberality in furnishing free return tickets to those members of the Association who came to the meeting over these roads or by the Lake.

*Resolved,* That the thanks of the Association be presented to the citizens of Burlington for the generous and elegant hospitality which they have extended to its members during the session.

## REPORT OF THE PERMANENT SECRETARY.

This report includes the business which relates to the interval between the commencement of the Buffalo meeting (August 15, 1866) and that of the Burlington meeting (August 21, 1867).

The Association now consists of five hundred and thirty-nine members. Eighty new members were added at the Buffalo meeting, and one hundred and sixty-six old members were struck from the list, on account of three years' delinquencies in the payment of assessments, their aggregate indebtedness to the Association amounting to fourteen hundred and ninety-four dollars ($1,494).

The financial condition of the Association is as follows: —

Between August 15, 1866 (the first day of the Buffalo meeting), and August 21, 1867 (the first day of the Burlington meeting), the income of the Association has amounted to one thousand and fifty-six dollars and seventy-seven cents ($1,056.77) of which thirty-five dollars and fifty cents ($35.50) came from the sale of copies of the printed Proceedings, and the balance from assessments.

The expenses of the Association for the same time have been eleven hundred and forty-two dollars and eighty-seven cents ($1,142.87), which may be classified, in general, as follows: —

| | |
|---|---|
| Cost of paper, printing, and binding the Buffalo volume of Proceedings, five hundred and thirty-four dollars and forty-eight cents, | $534.48 |
| Charges connected with the Buffalo meeting, forty-five dollars, | 45.00 |
| Charges connected with the Burlington meeting, twenty-six dollars, | 26.00 |
| Salary of the Permanent Secretary, five hundred dollars, | 500.00 |
| Postage, express charges, and other expenses, thirty-seven dollars and thirty-nine cents, | 37.39 |

The particular items may all be found in the cash account of the Secretary, which is herewith submitted as a part of his report. The balance in the hands of the Permanent Secretary August 21, 1867, is four hundred and twenty-two dollars and ninety cents ($422.90). There is no balance at present in the hands of the Treasurer.

JOSEPH LOVERING,
*Permanent Secretary.*

Burlington, August 21, 1867.

## CASH ACCOUNT OF THE

Dr. AMERICAN ASSOCIATION *in*

| | |
|---|---|
| Postage, | $10.00 |
| Ripley's bill for printing circulars, | 7.00 |
| Sibley's bill for express charges, | 2.00 |
| Sawin's express, | 1.25 |
| Postage, | 6.00 |
| Salary of Permanent Secretary, | 500.00 |
| Journey to Burlington in May, | 26.00 |
| Harris's bill as clerk, | 45.00 |
| Thirty-four Reams of Paper, | 221.76 |
| Paper for cover to Proceedings, | 6.63 |
| Postage, | 5.00 |
| Fox's bill for printing, | 75.07 |
| Fox's bill for printing, | 47.10 |
| Assignee's bill for printing, | 153.60 |
| Abbott for binding Proceedings, | 23.32 |
| American Academy for freight, | 5.00 |
| Sawin's Express, | 4.30 |
| Blank book for records, | 1.00 |
| Postage, | 1.94 |
| Discount on drafts, | .90 |
| | $1,142.87 |
| Balance to next account, | 422.90 |
| | $1,565.77 |

## PERMANENT SECRETARY. Cr.

*Account with* JOSEPH LOVERING.

| | |
|---|---|
| Balance from last account, . . . . . . . | $66.44 |
| Assessments (from No. 184 to No. 420 of Cash Book) including the sale of Proceedings, . . . . . . . . | 990.33 |
| Received from the Treasurer, . . . . . . . . | 509.00 |
| | $1.565.77 |

### REPORT OF THE AUDITORS.

THIS certifies that we have this day examined the above account of the Permanent Secretary, comparing the credits with the receipt-book and cash account, and the debits with the several vouchers; that we find the whole correct, and the sum of four hundred and twenty-two dollars and ninety cents ($422.90) credited to the next account.

(Signed) B. A. GOULD, } *Auditors.*
C. S. LYMAN, }

BURLINGTON, August 26, 1867.

## STOCK ACCOUNT OF THE PERMANENT SECRETARY.

### *Volumes Distributed or Sold.*

| VOLUMES. | I. | II. | III. | IV. | V. | VI. | VII. | VIII. | IX. | X. | XI. | XII. | XIII. | XIV. | XV. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Distributed to Members, | | | | | | | | | | 1 | 3 | 1 | 6 | 19 | 208 |
| Harvard College, | | | | | | | | | | | | | | 1 | 1 |
| Yale College, | | | | | | | | | | | | | | 1 | 1 |
| Boston American Academy, | | | | | | | | | | | | | | 1 | 1 |
| Boston Nat. Hist. Society, | | | | | | | | | | | | | | 1 | 1 |
| Boston Athenæum, | | | | | | | | | | | | | | 1 | 1 |
| Conn. Acad. Sciences, | | | | | | | | | | | | | | | 1 |
| Smithsonian Institution, | | | | | | | | | | | | | | 1 | 1 |
| Buffalo Nat. Hist. Society, | | | | | | | | | | | | | | | 1 |
| Buffalo Young Men's Library, | | | | | | | | | | | | | | | 1 |
| Buffalo Historical Society, | | | | | | | | | | | | | | | 1 |
| Foreign Societies,* | 5 | 5 | 5 | 2 | 5 | 4 | 3 | 3 | 4 | 2 | 2 | 2 | 2 | 4 | 57 |
| Sold, | | | | | | | 1 | | 1 | | | | 1 | 2 | 13 |
| Baltimore, Peabody Institute, | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | | 1 | 1 | 1 |
| Total, | 6 | 6 | 6 | 3 | 6 | 5 | 5 | 4 | 6 | 4 | 6 | 3 | 10 | 32 | 289 |
| Balance, April, 1867, | 54 | 105 | 240 | 227 | 426 | 288 | 520 | 841 | 943 | 880 | 821 | 938 | 1010 | 1161 | |
| Received from Binders. | | | | | | | | | | | | | | | 933 |
| Balance, April, 1868, | 48 | 99 | 234 | 224 | 420 | 283 | 515 | 837 | 937 | 876 | 815 | 935 | 1000 | 1139 | 644 |

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* See pages 175 and 176.

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